NATIONAL BUILDINGS ORGANISATION
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राष्ट्रीय भवन निर्माण संगठन

HAND BOOK RURAL HOUSING AND VILLAGE PLANNING

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HANDBOOK OF RURAL HOUSING AND VILLAGE PLANNING

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Foreword

The Manual on Rural Housing published a few years ago was a publication of rudimentary nature for the general guidance of those interested in raising the standards of rural housing.

The Handbook of Rural Housing and Village Planning is the result of a long and patient research throughout the country. It is a comprehensive publication primarily for the guidance of engineers, architects and officials connected with the technical aspects of rural housing and planning.

This Handbook is being published at a time when the importance of rural planning is being increasingly realized in the country. I hope this book will be a source of inspiration and guidance to all those who are connected with rural planning and give impetus to the village housing programmes.

New Delhi,
June, 1966.

Mehr Chand Khanna
Minister for Works, Housing
& Urban Development.

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PREFACE

The National Building Council at its 4th meeting held in 1961, resolved that the National Buildings Organisation should take up as a long term project, the preparation of a handbook on village planning, housing and construction for the benefit of technical staff working in rural areas.

As there was a pool of experience in the country on this subject in the Rural Housing Wings attached to six engineering colleges, Rural Housing Cells of State Governments and offices of the Chief Engineers of PWDs, they were consulted regarding the scope and contents of the book. The views and suggestions offered by them have been taken into account in drawing up the frame work of this book. The book is divided in 16 Chapters. The draft of each chapter was widely circulated for comments and the chapters were finalized after considering the views and suggestions received from various authorities interested in the subject.

The book describes the physical, social and economic background of Indian villages, a thorough understanding of which is essential in dealing with the problems of rural development. It sets forth in detail the guide lines for village planning, taking into account the various elements like physical characteristics of the village, housing pattern and density of population. The types of information necessary for the planner to evolve a rational plan, have been enumerated. Building materials and methods of construction suitable for rural areas, have been dealt with in detail in two separate chapters. The provision and maintenance of water supply and sanitary facilities and other services in the village has also been included. The book contains a number of typical layout plans of villages and building designs and also formulae and data for use in the design of rural structures.

Shri J. K. Varshneya, former Deputy Director and Shri O. N. Mathur, Assistant Director of this Organisation, who have prepared the Handbook, have taken great pains in collecting and compiling vast and varied information in a single volume. It is our sincere hope that officers and technical personnel, engaged in rural reconstruction and development, will find this volume useful in their day-to-day work.

We wish to place on record our thanks for the assistance rendered by Shri K. R. Jani, Architect, Ministry of W. H. & S. who prepared most of the drawings in this book. Our thanks are due to Shri K. L. Dutta, Scientist, Central Building Research Institute, Roorkee who wrote the Chapter on "Rural Landscape and Arboriculture" and to Shri I. K. Bhalla, former Assistant Director of this Organisation, for his help in the preparation of the Handbook.

C. B. PATEL,
Director,
National Buildings Organisation,
New Delhi.

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"If the Village Perishes India will Perish Too".

—Mahatma Gandhi

"An ideal Indian village will be so constructed as to lend itself to perfect sanitation. It will have cottages with sufficient light and ventilation built of materials obtainable within a radius of eight kilometres. The cottages will have courtyards enabling householders to plant vegetables for domestic use and to house their cattle. The village lanes and streets will be free of all avoidable dust. It will have wells according to its needs and accessible to all. It will have houses of workshop for all, also a common meeting place, a field common for grazing its cattle, a cooperative dairy, primary and secondary schools in which basic education will be the central fact, and it will have panchayats for settling disputes. It will produce its own grains, vegetables and fruits and its own khadi......."

—Mahatma Gandhi

A house is not merely a place to take shelter from the rain or the cold or the sun. It is, or should be, an enlargement of one's personality and if human welfare is our objective, this is bound up with the house.

—Jawahar Lal Nehru

I

Rural Housing in India—Problem and Progress

1.1 The Problem of Rural Housing

1.1.1 Mahatma Gandhi once remarked "If the village perishes, India will perish too". This cryptic statement emphasizes the imperative need to initiate and implement schemes of rural development and reconstruction. In the overall scheme of rural development and reconstruction, housing should find an important place, for a house is not only a place for protection from the vagaries of weather, but also for an enlargement of one's personality; it is an institution in itself.

1.1.2 Some idea of the existing conditions in rural areas is provided by the data collected by the National Sample Survey in its 12th round (March to August, 1957). About 73 per cent of the households live in two rooms or less. 73 per cent of the households live in 'katcha' structures whose plinth is made of mud and where walls and roofs are built of grass, reeds or thatch with or without any plaster. 97 per cent of the households have no latrines. 93 per cent of the households have no bath-rooms. 45 per cent of the households use part of living room as kitchen. Only 0·35 per cent of the households have got protected pipe water-supply.

1.1.3 According to 1961 Census there are 5,67,169 villages in the country where 35·98 crore persons forming 82 per cent of the total population reside. There are 6·51 crore occupied residential houses in rural areas, out of which more than 5 crore houses have to be either re-built completely or improved substantially. Even on the basis of an average expenditure of Rs. 1000 per house for reconstruction and/or improvement, the total sum required would amount to the colossal figure of Rs. 5000 crores. These figures serve to indicate the vast magnitude of the rural housing problem and the urgent need to implement well considered housing programmes in rural areas.

1.1.4 Improvement in housing conditions in the rural areas is considered essential not only because it would enable the villager to lead a clean and healthy life, but also because of the direct impact which the improvement of housing conditions is likely to have on the economy of the rural areas. When village families move into new and improved houses in replanned villages with proper streets and drains, safe drinking water, open spaces, play grounds, community centres, etc, they would naturally want to live better, and would be motivated to exert greater efforts towards improvement of their agricultural and industrial production, which alone can provide them with the additional resources required to meet their growing demands for better living. The housing programme, is, therefore, expected to stimulate, at one and the same time, an increasing demand for goods, and increasing capacity to produce the wanted goods. Improvement of housing conditions and provision of connected facilities should also assist in slowing down the migration of population from the rural to the urban areas, and thus help to reduce the complications and insanitary conditions created by overcrowding in the various towns and cities of the country, where housing programmes cannot possibly keep pace with the growing demand for houses.

1.2 Progress of Rural Housing in India

1.2.1 The progress achieved so far in the field of rural housing in the country has been rather insignificant. Prior to the First Five Year Plan, little or no attention appears to have been paid to this problem. The necessity of ameliorating rural living conditions was recognized in the First Five Year Plan, but the Planning Commission observed that "having regard to the limitation of finanncial resources, a satisfactory programme of rural housing during the period of the Plan cannot be envisaged." The Planning Commission expected State Governments to do something in this direction by granting long-term interest-free loans to villagers for building houses, and disseminating information regarding construction of cheap houses. But due to paucity of funds nothing substantial could be done in the matter. Some houses were, however, built here and there under the N.E.S. and Community Development Programmes, but here again the number was too small to make any impact on the problem.

1.2.2 The Second Five Year Plan made a provision of Rs. 5 crores for Rural Housing. The Ministry of Works, Housing and Rehabilitation* was of the view that utilization of the meagre amount by itself for the grant of house-building loans to villagers on the lines of say the Low Income Group Housing Scheme, could hardly be expected to yield any worthwhile results. Since certain other Ministries had also been allocated funds for the implementation of various rural development programmes falling within their respective spheres of activity, it was considered that rural housing activities should be effectively coordinated with other connected programmes of rural development in order to ensure that the rural areas derived the maximum advantage from the limited resources available in the Plan for this purpose. For example, the Ministry of Home Affairs which had funds for provision of financial assistance in the shape of grants to scheduled castes, scheduled tribes, etc, could with advantage give priority to those members of scheduled castes and scheduled tribes who happened to be residing in the villages in which housing programmes were undertaken. The Ministries of Health, Community Development and Industry could similarly give priority to improvement of water supply and sanitation, setting up of cooperatives and suitable village and small scale industries, etc, in these villages, not only with a view to ensuring the necessary basic amenities and reducing building costs but also providing employment opportunities of a steady nature to the poorer sections of the village community. It was expected that action on these lines would produce substantial results in the areas selected for development which would then be a source of inspiration to inhabitants of adjoining areas, and serve as models that could be duplicated elsewhere with the help of local initiative and resources.

*Now the Ministry of Works, Housing & Supply.

1.2.3 *Introduction of the Village Housing Projects Scheme*—This Scheme was introduced by the Ministry of Works, Housing & Rehabilitation in August, 1957. It seeks to ensure a coordinated approach to the problem of housing and connected programmes of rural development and is based on the following principles:

1. Aided self-help: Outside aid, particularly, financial, to be restricted to the barest minimum. Adequate technical guidance should, however, be made available free of charge;
2. An all-round economic development of the rural areas in which the programme is undertaken to enable villages to maintain their houses and to repay loans taken by them for building their houses, without any undue hardship;
3. Improvement of housing conditions in a village or the physical reconstruction of a village to be treated as a long-term programme spread over a period of say 10 years. so as to keep in step with the improvement of economic condition of the villagers;

The Village Housing Projects Scheme envisages selection of 5000 villages all over the country in suitable and economically progressive development blocks, where housing projects will be undertaken. A sum of Rs. 5 crores was earmarked for this purpose in the Second Five Year Plan, out of which Rs. 3·7 crores were actually utilized. In the Third Five Year Plan, a sum of Rs. 12·7 crores was provided for this scheme. The Scheme lays considerable emphasis on the technique of aided self-help and mutual aid and the beneficiaries are required to contribute one-third of the cost of construction or improvement of a house in the form of cash, material or manual labour. The progress of the Scheme is given in Table 1.

1.2.4 *Rural Housing Cells*—The Village Housing Projects Scheme provides for the establishment of Rural Housing Cells at the headquarters of each State under the immediate charge of a senior technical officer. The functions of the Cells are as follows:

(i) to arrange physical (engineering) and socio-economic surveys of the selected villages;

(ii) to draw up Master Plans for the selected villages on the basis of the data gathered as a result of the engineering and socio-economic surveys;

(iii) to prepare suitable designs and specifications for houses having due regard to local conditions, such as climate, living habits, customs, local materials, etc;

(iv) to provide overall technical guidance to local authorities in execution of projects under the Scheme; and

(v) to generally ensure that the money available for the purpose is properly spent.

1.2.5. *Rural Housing Wings*—Research, training and extension programmes being essential for the success of any rural housing scheme of the nature envisaged in the Village Housing Projects Scheme, the Government of India have set up six Research-cum-Training-cum-Extension Wings for rural housing in six engineering institutions located on a regional basis. The Wings serve various regions of the country as follows:

1. Rural Housing Wing, Birla Vishvakarma Mahavidyalaya, Vallabh Vidyanagar	Gujarat, Madhya Pradesh and Maharashtra
2. Rural Housing Wing, College of Engineering, Bangalore	Andhra Pradesh, Kerala, Madras and Mysore
3. Rural Housing Wing, College of Engineering, Chandigarh	Himachal Pradesh, Jammu & Kashmir and Punjab
4. Rural Housing Wing, School of Planning and Architecture, New Delhi	Delhi and Rajasthan
5. *Rural Housing Wing, University of Roorkee, Roorkee	Bihar and Uttar Pradesh
6. Rural Housing Wing, Bengal Engineering College, Sibpur	Assam, Manipur, Orissa Tripura and West Bengal

The functions of these Wings are threefold, *viz.,*

(a) to impart training to the officers responsible for the implementation of the Village Housing Projects Scheme, especially the Overseers working in Community Development Blocks;

(b) to conduct research relating to locally available building materials, techniques of construction, design of houses and village planning;

(c) to carry out extension and demonstration work in the field for trying out and demonstrating results of research and new construction techniques.

The Wings function under the overall guidance of the National Buildings Organisation, which makes appropriate arrangements for coordinating their activities. There is a Central Advisory Committee which comprises of the Heads of the six Wings, representatives of the concerned Central Ministers and authorities and representatives of farmers, etc. This body is responsible for guiding the working of the Wings in general and to advise the Government of India for their efficient functioning. Each Wing has its own Regional Advisory Committee comprising of the Development Commissioners of concerned States, authorities concerned with housing in the States, representatives of farmers, State Rural Housing Cells, National Buildings Organisation, etc. This body is responsible for chalking out the specific programme of the Wing as well as to suggest problems that need investigation.

An important aspect of Rural Housing Schemes is the Construction of demonstration houses in villages, incorporating the results of research. The Ford Foundation has made available an assistance of 200,000 dollars for the Third Five Year Plan period to be spent by these Wings on the construction of demonstration houses in selected villages. In each selected village, a set of 8 demonstration houses (2 of each specification) are built. The underlying idea is to demonstrate new ideas in house design, village planning, utilization of new or improved locally available materials and new construction techniques.

1.3 Place of Village Housing in the Overall Housing Programme

1.3.1 Table 2 (*See* p. 4) shows the place of village housing in the overall housing programme of the government.

* Closed from 31-3-1966. The Delhi Wing now looks after its work.

TABLE I

VILLAGE HOUSING PROJECTS SCHEME

Construction/Improvement of Houses

(PROGRESS CHART)

Sl. No.	Name of State/ Union Territory	Number of Villages			Amount of Loan				Number of Houses		Up to the quarter ending
		Allotted	Selected	In which Scheme is actually in operation	Sanctioned		Disbursed		Sanctioned	Completed	
					G.F.	L.I.C	G.F.	L.I.C.			
1	2	3	4	5	6	7	8	9	10	11	12
					Rupees	in	lakhs				
1	Andhra Pradesh	450	450	188	83·77	8·00	45·79	..	5,027	2,397	31-3-64
2	Assam	150	150	..	..	..	..	..	..	..	30-9-65
3	Bihar	600	562	70	4·70	..	4·03	..	399	80	30-6-65
4	Gujarat	195	54	29	17·85	..	15·87	..	1,245	791	30-6-65
5	Jammu & Kashmir	50	..	..	..	..	..	..	..	..	31-3-65
6	Kerala	200	192	188	24·38	8.77	21·54	8·32	2,287	1,423	31-3-65
7	Madhya Pradesh	350	306	95	36·00	..	38·88	..	2,735	1,245	31-3-65
8	Madras	350	455	151	35·72	19·57	33·00	11·85	3,276	2,018	30-6-65
9	Maharashtra	355	413	341	148·29	..	120·15	..	11,593	3,362	31-3-65
10	Mysore	300	337	337	78·25	5·00	69·58	4·66	7,226	3,860	31-3-65
11	Orissa	240	251	181	40·66	..	31·93	..	3,278	1,526	31-3-64
12	Punjab	200	200	85	40·55	4·46	37·18	4·30	2,415	939	31-3-65
13	Rajasthan	300	404	240	77·03	7·00	60·81	4·79	6,340	2,795	30-9-65
14	Uttar Pradesh	850	1,227	248	65·69	..	56·66	..	5,603	2,332	31-3-65
15	West Bengal	300	300	180	17·33	..	14·68	..	3,291	2,782	31-3-65
	TOTAL	4,890	5,301	2,333	590·22	52·80	549·90	33·92	54,715	25,550	
16	Himachal Pradesh	20	20	17	6·17	..	5·89	..	377	284	31-3-65
17	Manipur	20	3	3	3·86	..	1.50	..	168	..	30-6-65
18	Pondicherry	5	..	..	..	..	..	..	..	..	31-3-65
19	Tripura	20	18	13	2·74	..	2·57	..	309	211	30-6-65
20	Delhi	20	13	11	7·04	..	5·59	..	326	260	30-9-65
21	A. & N. I.	20	..	..	..	..	..	..	..	..	31-3-65
22	Laccadives	5	5	5	0·60	..	0·46	..	42	3	31-3-65
	TOTAL	110	59	49	20·41	..	16·01	..	1,222	698	
	GRAND TOTAL	5,000	5,360	2,382	610·63	52·80	565·91	33·92	55,937	26,248	

TABLE 2

Scheme	2nd Plan Expenditure in crores	3rd Plan Outlay in crores
Village Housing	3·8	12·7
Subsidised Industrial Housing .	22·25	29·8
Dock Labour Housing	—	2·0
Slum Clearance, Slum Improvement and Construction of Night Shelters	12·05	28·6
Low Income Group Housing . .	31·9	35·2
Middle Income Group Housing in Union Territories . . .	0·3	2·5
Plantation Labour Housing . .	0·1	0·7
Land Acquisition and Development	2·2	9·5
Experimental Housing, Research and Statistics	—	1·0

1.4 Future Approach to Rural Housing

1.4.1 It is clear from the magnitude of the problem indicated in para 1.1.3, that a rural housing programme on the scale necessary to meet the situation adequately could hardly be financed completely by the resources that could be made available by Government alone in the immediate or even foreseeable future. It is in recognition of this fact that the Village Housing Projects Scheme formulated by the Government of India lays considerable emphasis on the techniques of aided-self-help and mutual aid. This approach has to be continued and further avenues of villagers' participation in the rural housing programme have to be explored.

2 Socio-Economic Aspects of Housing

2.1 Socio-Economic Surveys

2.1.1 Before any physical layout of the village is prepared, it becomes necessary to conduct a socio-economic survey as a prelude to the scheme of village reconstruction. Such surveys enable us to study not only the existing socio-economic conditions but also to measure and compare the extent and direction of social and economic changes that take place in the process of techno-economic development of a society.

2.1.2 In the context of rural housing schemes, the aims and objectives of such surveys are:

(a) Assessment of peoples' demand for housing in the context of their overall demand pattern,

(b) Assessment of people's resources, income and expenditure, their indebtedness etc., with a view to estimating their financial capacity,

(c) Study of the present population according to age, sex, marital status, etc, and its growth in a historical perspective with a view to projecting the future trends of growth so as to estimate the present housing requirements including civic, cultural, recreational and educational amenities making allowance for future as well,

(d) Assessment of peoples' attitude, their habits, customs preferences, etc, in relation to their impact on housing and planning.

2.1.3 For the purpose of housing and planning we should follow the census method of survey, *i.e.*, the complete enumeration of the households. A model household schedule has been given in Table 1. In addition to the household schedule it is also necessary to collect the overall data of the village from different sources (including the village records, the C.D. Blocks, the Tehsil and even a few experienced farmers). A model village schedule has been given in Table 2.

2.1.4 The success or otherwise of socio-economic surveys would ultimately depend upon the designing of the schedules and the method of conducting the investigations by the investigators. The schedules must be brief, simply worded, logical and at the same time they must cover the entire purpose. The investigators on the other hand must be well-trained, well behaved and temperamentally rural. They should be able to pose the questions in simple words and right perspective. Proper checking and scrutiny of the data should also be done by competent supervisors.

2.2 Social Aspects of Rural Housing

2.2.1 Majority of people in rural areas are unable to think of a clean and healthy life and good sanitation for themselves. It is therefore, felt that the problem of rural housing should be considered in the context of problems more related to human beings than to their physical surroundings. It is a question of mental hygiene and should be included in the health programme of the nation. No amount of money spent on rural housing will give Indian villages a modern look unless the individuals living in those houses are made modern in their outlook as well as behaviour. This change of outlook and behaviour can only be brought about by giving them better education. If we are able to create a basic urge in them for better living even the old 'kucha' houses will start presenting a new look. It is not the earth which is responsible for the dirty living inside the houses. It is the man and the family as a whole, devoid of a modern outlook, better education, social responsibilities, and clean habits, which are responsible for this state of affairs in their houses, inside and outside. It is a human problem and we should, therefore, concentrate on changing the human attitudes and habits. Unless people are improved and made to feel strongly for better housing conditions, not much is going to be achieved. To illustrate this we have not to go far. In cities where drainage facilities are available, where many storeyed colonies for labour and other types of workers have been built surrounded by roads and parks, the condition inside those 'pucca' houses are no better than in slums and also vary from individual to individual. In many houses the inmates do not even clean their latrines soon after they use it. They are as filthy or even filthier than any dirty spot in the villages. Similarly other rooms, bath rooms, stair-cases, etc, of a number of these houses are dirty dungeons. In any case, inside they are no better than the slums inspite of their better appearance from outside. As compared to this, in most of the slum areas individual houses are cleaner than many of the 'pucca' houses of these labour colonies. It is the men living in them who are responsible for this.

2.2.2 It is, therefore essential that a programme which should enable the villager to understand the necessity of a cleaner and healtheir life be undertaken. This would naturally result in better housing conditions in the rural areas and will also have a direct impact on their economy. Our efforts to build new and improved houses with proper streets and drains are no doubt laudable but our previous efforts in this direction do not prove conclusively that giving them a better house to live in, alone creates an urge in them to live better and to exert more towards improvement of their agricultural and industrial production. We should make a coordinated programme for creating a strong urge for a cleaner and healtheir life in the rural folk of our country. Ministries or Departments directly or indirectly concerned with this subject would participate in the programme. The Ministries of Education, Health, Community Development and Home Affairs at the Centre and the Departments of Education, Social Welfare, Development and Panchayats and Public Health in the States, can be yoked together to prepare such a coordinated programme. It will include items of education on better living, social responsibility, mental and physical hygiene, self help and economic development. The entire programme will have to be brought home to the rural public through intensive publicity based entirely on visual aids.

2.3 Rural Housing Cooperatives

2.3.1 *Introduction*—Cooperation is the essence of community life and it embraces every sphere of human activity. Cooperation as a method of mutual and joint approach to solve certain common problems is a very old phenomenon. But as an organised movement to bring about improvement in the socio-economic life of the people in India, it took its origin in the beginning of this century, with the enactment of the Co-operative Credit Societies Act of 1904. The Co-operative Societies Act of 1912 extended the scope of activities of co-operative societies from credit to non-credit operations.

TABLE 1

HOUSEHOLD SCHEDULE

Village——————————Tehsil——————————District——————

Household No.—————— Name of the head of H.H.——————————

Part I (Socio-Economic)

BLOCK I : Details regarding the household

Religion——————Caste—————— Scheduled caste——————Scheduled tribe
Backward class

Main occupation of the H. H.——————————The right of H.H. to the house :
Owner tenant

BLOCK II : Household members (including the head) with their particulars :

Sl No.	Relation with the head of H.H.	Age (yrs.)	Sex M/F	Marital status NM/M/W	Educational level I/R/RW or level attained School going	Economic status E/D	Occupation C/T/A/L/S/O	Remarks

BLOCK III : Land utilization in hectares (excluding the house plot)

Total land owned by H.H.	
Land cultivated	
Land irrigated	

BLOCK IV : Livestock	Number
Milch animals	
Ploughing & service animals	
Goats and sheep	
Poultry heads	
Others (specify)	

BLOCK VI: Indebtedness

Are you in debt ?—Yes No

If yes, amount of debt——————

Purpose

BLOCK V : Income of the H. H. (previous year)

1. Cultivation and crafts.

Name of the produce	Unit	Output	Value (Rs.) per unit	Value of the produce (Rs.)

Total (cultivation & crafts) Rs. ——
2. Trade & Business Rs. ——
3. Labour & Service Rs. ——
4. Other sources Rs. ——

5. TOTAL (GRAND) . . . . Rs. ——

NOTE :

H.H. Household
M Male
F Female
NM Never Married
M Married
D Divorced
W Widow/Widower
S Separated
I Illiterate
R Read only
R.W. Read & Write
E Earner
D Dependent
C Cultivator
T Trader
L Agricultural Labour
S Service
A Artisan
O Others

Part II (Physical)

BLOCK I : Housing particulars :

Type	No	Remarks
Living rooms		
Store (if separate)		
Kitchen (if separate)		
Cattle sheds (if sep.)		
Verandah		
Bathroom (if sep.)		
Any other room (if sep.)		
Total built-up area		
	(sq. m.)	
Total area of the house plot		
	(sq. m.)	

BLOCK II : Quality of the house

1. *Type of walls* :
Burnt bricks Unburnt bricks
Mud Others————— —————
(Specify)

2. *Type of roof* :
Thatched Tiles Mud
Others—————
(Specify)

3. *Type of floor* :
Kuccha Pucca Others —————
(Specify)

4. *Fencing arrangements* :
Complete Partial None

5. *Structure of the house* :
Kuccha Pucca Mixed

6. *Condition of the house* :
Dilapidated Good
If dilapidated : Part Whole

BLOCK III: Cooking arrangements :

Separate kitchen In living room
In verandah In open Others
(Specify)

BLOCK : IV : Drinking water facilities :

Inside the houseplot Outside the houseplot
Source : Tap Handpump
Kuccha well Pucca well
Others
If outside the houseplot : distance —————
(m)

BLOCK V : Sanitary conditions :

1. Latrines
Sanitary Non-sanitary No

2. Drains :
Kuccha Pucca No

3. Disposal of waste water :
Soakpit Street None

4. Distance of the manure pit from the house (if any)
(m)

Part III (Opinion Survey)

Do you want : (*a*) a repair in the house :
(*b*) addition of living rooms :
(*c*) a new house :

Would you like to take a loan from the Government for this purpose ?
Yes No

If yes amount: Rs—————

What would be your contribution for this purposes ?
(*a*) Cash: Rs—————
(*b*) Materials————— —————
(kind) (kind)
(*c*) Labour : Yes No

Would you like to become a member of the cooperative housing society for this purpose ? Yes No

Would you like to put your cattle in the common cattle shed which will be for a group of households ? Yes No

REMARKS

Name of the investigator :
Signature
Date

Name of the Scrutiniser
Signature
Date

TABLE 2

VILLAGE SCHEDULE

Village————————Tehsil————————District ————————

CD Block NES Block None

I. POPULATION AND HOUSEHOLDS :

Year	No. of houses	No. of H.H.	Population	Remarks
Last census year				
Date of survey year				

II. LAND : (IN HECTARES)

Type	Private	Panchayat	Govt.	Total
Cultivable				
Cultivable waste				
Abadi (built up)				
Open space available for expansion of abadi area				
Others (specify)				
TOTAL				

III. ELECTRICITY :

Is there electricity Yes No

IV. EDUCATIONAL CENTRES

Type	If not available distance from nearest
Primary School Yes No	
Middle School Yes No	
High School Yes No	
Others (Specify) Yes No	

VI. RELIGIOUS CENTRES, ETC

Temple:	Yes	No
Mosque:	Yes	No
Gurudwara:	Yes	No
Church:	Yes	No
Cremation ground:	Yes	No
Grave yard :	Yes	No
Others (specify):	Yes	No

V. HEALTH CENTRES

Type	If not available distance from the nearest
Public dispensary Yes No	
Hospital Yes No	
Maternity home Yes No	
Veterinary hospital Yes No	
Others (specify) Yes No	

VII. RECREATIONAL CENTRES

Parks :	Yes	No
Playground :	Yes	No
Theatre :	Yes	No
Others (specify):	Yes	No

VIII. ADMINISTRATIVE & OTHER FACILITIES

Panchayat ghar :	Yes	No
Patwari ghar :	Yes	No
Cooperative society:	Yes	No
Others (specify) :	Yes	No

IX. PUBLIC UTILITY CENTRES :		
Rest Houses :	Yes	No
Post Office :	Yes	No
Telegraph Office :	Yes	No
Telephone Office :	Yes	No
Railway Station :	Yes	No
Others (specify)	Yes	No

X. SOURCES OF WATER :	
Source	Number
Kutcha wells	
Pucca wells	
Tubewells/handpumps	
River/stream	
Tank	
Central	

XI. DRAINAGE :		
Sewage :	Yes	No
Covered drain :	Yes	No
Open drain :	Yes	No
Others (specify) :	Yes	No

XII. OCCUPATIONAL DISTRIBUTION OF HOUSEHOLDS :
1. Owner cultivation
2. Cultivating tenants
3. Agricultural labourers
4. Artisans
5. Traders
6. Money-lenders
7. Professional service
8. Others (specify)

The Third Five Year Plan lays down that 'in a planned economy, co-operation should become progressively the principal basis of organization in many branches of economic life'. It has been suggested that housing, besides certain other fields, is one of the useful fields for the application of co-operative method.

2.3.2 *Housing Co-operatives in India*—Housing through co-operatives in India had no ceremonial start. The movement started in Bombay as early as in 1915 and it received impetus when the Government announced State assistance to co-operative housing societies in 1924. Gradually more and more housing co-operatives came into existence in other States too owing to the assistance given by the State Governments. With the establishment of the National Government, more and more attention is being paid to this problem. The various housing schemes introduced under the successive Five Year Plans have provided added incentives to housing co-operatives by offering larger subsidies and loans.

By and large the housing co-operatives have been functioning in urban areas. The movement has not entered rural life in any appreciable way. It is only with the introduction of the Village Housing Projects Scheme that some housing co-operatives have been established in certain villages of the country.

At the end of 1956 there were 637 rural co-operative societies for housing in the country and their present number is estimated to be over 1000.

The Village Housing Projects Scheme launched by the Union Government in 1957, offers financial assistance to the residents of selected villages or to co-operatives of such persons for building of houses on an "aided self-help" basis. In granting loans, preference is given to co-operatives of such persons.

The scheme also provides for selection of a group of 4 to 6 adjoining villages so that co-operative societies may be established for production of building materials, such as brick, lime, doors, windows and hardware, such as locks and hinges.

A review of the progress of housing co-operatives as a whole shows that their contribution towards the solution of the housing problem which is enormous is not appreciable. Further the number of the housing co-operatives functioning in rural areas is negligible. The movement has to be promoted with a greater stimulus.

2.3.3 The scope for co-operative societies in rural housing lies in several directions. Housing co-operatives can function to obtain loans from Government and distribute it to members. Technical guidance, bulk purchase of building materials or components, such as lime, brick, doors and windows, hinges and locks can also be arranged by the co-operative society or, in the case of manufacture of materials, a few neighbouring villages can form a separate society to serve the purpose by large-scale production of the commonly required items. A co-operative society can maintain a sustained enthusiasm on the part of its members in house building activity since several households of a village are simultaneously committed to build houses and a team-spirit of people devoted to like interests would prevail. Usually, in a group of villages, among the well-to-do households a few are exposed to urban contact and stimuli and they may aspire for improved housing. But their efforts at it become isolated instances which the average villager regards as a natural function of conditions of wealth and affluence. A co-operative society, therefore, becomes an appropriate institutional approach as it signifies the enlistment (by persuasion or voluntary natural response) of the villagers' interest to improve conditions of housing.

Loans and subsidies or releasing of one's own funds for house-building can often result in a season of building work being started by several people, but not even carried forward half-way for want of masons, carpenters or certain materials. If done through co-operatives, needs for skilled work and for materials among prospective builders can be co-ordinated and handled as a matter of basic and common concern.

Co-operatives can facilitate promising efforts when we think of housing in relation to the development plan of the whole village. The housing activity operates or should operate in the context of a redevelopment plan. The village, by stages, has to achieve what is visualised in the village plan approved by the Panchayat. This achievement may often need minor sacrifices on the part of some households to surrender land on compensation or to exchange land to enable one to build a house, or to shift to a new site for building a better house. Efforts involving adjustments and sacrifices can thrive more successfully under co-operative efforts.

Many of our villages are from the point of view of population, small and medium in size and the number of households that can build houses at any time within one village would be small. Therefore, a co-operative society covering a few villages can work better as there would be a larger number of such house-holds.

2.3.4 Co-operatives in rural housing will serve a further need. In any field, modern co-operation is an institution that leads the villager to develop loyalties and interests across caste or other local considerations of an unhealthy nature. The villagers should learn to unite as adult members with a social-*cum*-individual interest beyond their family, kin-group and caste. Co-operation in different fields to achieve the individual's interests without thwarting the interests of others is therefore, the most fitting to rural India. A housing co-operative in a village is not to be regarded as just a body with the sole aim of building a few houses. It has the far-reaching importance of creating a new field that contributes to the training of the villager to change some of his attitudes in a manner favourable to improve production and enhance welfare as a whole.

2.3.5 Although the scope of housing co-operatives in rural India is very promising, the conditions obtaining today are, in several aspects, very unfavourable for co-operatives to emerge and prosper. Numerous reports and opinions of the Press convey the very limited success or even failure of co-operatives in many parts of India. Critical studies about success of co-operatives offer equally discouraging contents to read. Daniel Thorner, in his recent publication points out that what contributes most effectively to the success of rural co-operatives is a "modicum of social equality, political democracy and economic viability among the villagers". Generally we find that villagers lack organisational ability, particularly across caste boundaries and in matters involving finance. Considerations of caste and favouritism fostered by the ties of kinship dominate the village which side track and dwindle efforts at organising for individual and community goals.

In rural India, there is no tradition to organise and avail of opportunities for bringing in finance for any development programmes whether it benefits each household or the community as a whole. Indigenous systems of money lending has left the individual related to a creditor and not to a group or an organisation, and this feature, by its very social disposition, takes decades to wane out. The villager, therefore, needs a slow conversion of his attitude in favour of collective effort to serve individual needs of loan or materials for housing or for any other developmental activity. In view of these facts, it is reasonable to state that if rural housing co-operatives have not made any significant headway it is not because they cover the field of housing but because the co-operative movement has yet to take a firm root in the rural soil. This calls for the help of the Extension Officers who are today

employed on the staff of Development Blocks in arousing the spirit of co-operation.

2.3.6. Rural Housing co-operatives, where started, should survive their teething troubles, fare forward and set an example in stimulating people to patronize the field of co-operation. To achieve this the help of the Extension Officers for Co-operation (usually employed on the staff of the Development Block) should be sought whenever possible. What is important now, is the quality of functioning of the co-operatives rather than an unhealthy increase in their number.

2.4 Aided Self-Help in Rural Housing

2.4.1. *Aided Self-help*—What is it? As the name implies, aided self-help is a method to utilize the many man-hours that are available in most rural areas in the form of unused leisure time which represents an enormous reserve of man-power, together with some form of aid from the community or other source so that man may, through his own efforts, using his own spare time, improve his shelter to an extent that he never could do alone and unsided.

2.4.2 *Some Aspects of Aided-Self-Help*—In highly organized societies acceptable housing is usually constructed by qualified builders, under contract, using commercial materials assembled by skilled labour. After construction the family moves in and undertakes to pay for having the house built for them by others than themselves. For many, this process costs too much. It often costs too much even for the State which must subsidize the family. However, if the greatest resource of all—the otherwise unused man-power of the families themselves—can be combined with aid from the community, improved housing may be provided within the means of the individual and the community.

On the other hand, in many developing countries like India, where traditional self-help is the accepted way to build a house, local materials and the family's labour are used to construct a home which, far too often, is a small insanitary, vermin-ridden hut. Although for many, this is an unsatisfactory answer, it is the best they can do, unaided But, under the aided self-help principle, their labour and the use of local materials will be supplemented by aid in forms which will help them to build better houses, perhaps on better site, possibly using a small supply of heretofore scarce and expensive materials. This would be within the means of the individual and the community. This is the approach which the Village Housing Projects Scheme seeks to follow in rural areas.

Aided self-help does not avoid many of the problems common to any housing programme. In fact, it often introduces additional complexities. In any event, the end result seems to justify the means. To the usual problems of Governmental organization, lack of trained indigenous personnel, and the difficulties of planning and programming must be added with the realization that, under aided self-help, once a solution is found, the attitudes, emotions, traditions, customs, and beliefs of the public will determine the pace of housing improvement.

2.4.3 *Inspiring the Desire for Improvement*—Thus, when a practical basic solution for housing improvement is at hand, the matter of inspiring in the mass of the ill-housed, the desire to improve their lot often becomes of utmost importance. Unfortunately it is extremely difficult to convince the rural folk of the good points underlying the improvement scheme. They might even question the very motive and fail to understand that some one is trying to help them. Poverty, ill health and lethargy of the people add to this difficulty. Under even more favourable conditions than those, a resistance to change or improvement is often encountered.

The only one answer to this problem seems to be community education. If people are not aware of their real needs, then measures must be taken to help them realize what their needs really are and to get them ready to do something about them and, of still greater importance, help them realize that a sound solution is available or can be developed.

Whatever be the nature of the problem, it stands out that the people must be convinced. And from this understanding emerges one cardinal principle that before contemplating the commencement of a programme it must be ensured that the leaders (chiefs, priests, political leaders, etc.) of the group affected, who help to develop the proposal, are fully informed or at least understand the facts involved and are convinced of the worth of the programmes. If this step is taken, these leaders will be in a position to influence mass thinking and correct adverse talk and erroneous interpretations before they gain some sort of credence through repetition.

2.4.4 *Organisation of Communities for Aided Self-Help in Housing*—Presentation to the general public is accomplished through media, such as radio, newspapers, books, pamphlets, posters, lectures, exhibits, group discussions and demonstrations; Community meetings are valuable. Visual aids make very good impression. Direct personal contact is effective in acquiring an insight into the community's real reactions and in clearing up misconceptions.

It has been found in group meetings that a straight lecture is the least effective technique; if local leaders formally participated in the meeting, effectiveness is increased. Charts or drawings are still better. A lecture supplemented by a film strip is the best of all.

Even then, a further refinement comes into the picture. In some areas, members of groups work best if they do not know, until completion of all of the houses, which one will be theirs. In other cases, people just will not work until they know which one of the houses the group is building is to be their own eventually.

Before launching the programme of actual rebuilding and housing through aided-self-help and mutual aid, it would be better to provide some training to village artisans in their particular building trades in consonance with the type of skill that is available in the villages. This will at least enable the skilled workers to have some sort of systematic background training to improve their working and to cope up with the work they are entrusted.

The improved methods of producing local building materials and better methods of construction should then be taught to the villagers. It may not be possible to tackle each builder. But a group of heads of families could be formed for giving instructions. Through different publicity media—films, lectures, illustrated leaflets—these techniques could be explained to the villagers. The Rural Housing Cells, the Rural Housing Wings, and the National Buildings Organisation can contribute to such a programme very substantially.

The actual scheme of housing and village planning should be prepared with the assistance of the Rural Housing Cells and the Community Development Blocks for implementation.

2.4.5 *Forms of Aid and Family Participation*—Aid also takes more tangible forms including, among others, technical advice in design, use of materials, and assistance during construction, financial assistance; labour, more often than not skilled labour to assist in the difficult phases of housing construction; land, or some form of secure land tenure; and the administration, organisation, and guidance of the whole improvement programme.

2.4.6 *Technical Aid*—Those who have worked with aided self-help housing have found technical advice and assistance one of the most effective tools for housing improvement. New uses for old materials, improvement in commonly used materials, and the development or introduction of new materials, all are examples of technical contributions to better housing through aided self-help and other means. Stimulation of the local building industry and technical assistance during its development are important functions. The Rural Housing Cells of the State and the Rural Housing Wings set up in six engineering colleges will provide the necessary technical aid in this respect.

2.4.7 *Variations of Self-Help*—Other variations of self-help include :

(a) The building of a one-room 'core' structure by skilled labour and of the other rooms later by self-help in Slum Clearance and Resettlement Projects.

(b) The 'self-help' production of materials and building elements; such as sand blocks, bricks and lumber, which are supplied to paid workers who build the houses;

(c) The building of foundation and walls by self-help and roof by skilled workers.

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3

Village Planning

3.1 Planning Approach

3.1.1. The foremost consideration in village planning and evolving house designs should be that the housing requirements of villagers are met and the effect of planning brings about radical changes in their way of life, which are socially necessary. For sound planning, it is necessary that it is based on knowledge of the villagers' existing socio-economic conditions, their difficulties with present living standards and estimate of their future housing requirements. In this connection the developments taking place in the region also merit consideration. The influence of cities on suburban villages, the extension of transportation facilities, increasing level of agricultural output by means of mechanical farming, by installation of tubewells and above all the influence of electric power and the developmental activities under the community development programme has to be considered and due allowance made for the influence of all these factors on the villagers' housing requirements.

3.1.2 While maximum attention has to be given to the planning of individual villages, some thought and consideration must be given to the regional planning. Certain community facilities like schools, markets, clinics, post offices, etc., cannot be provided in each village but have to be provided for, on a regional basis. A state should be prepared. This work should be undertaken by on the basis of topography, climate etc. and regional plans for providing the abovementioned community facilities should be prepared. This work should be undertaken by the State Rural Housing Cells in collaboration with Rural Housing Wings of the region and block development authorities.

3.2 Physical Survey

3.2.1 After socio-economic survey has been carried out as explained in Chapter 2, a physical engineering survey of the village should be carried out by plane table on a scale of 1:500. The survey should indicate

(1) All existing houses, the built up area of each plot as well as open spaces attached to each.

(2) The condition of the house, *viz*., 'kutcha', 'pucca' or dilapidated.

(3) Main entrance of the house marked by an arrow.

(4) Spot levels of the village.

(5) The boundary of the village.

(6) Land available for expansion of the village.

(7) All trees, wells, tanks, public buildings, approach roads, internal streets and other important existing features.

3.2.2 Detailed contoured survey of the area and a key plan showing the village in relation to its surrounding area, existing roads, canals, streams, etc, should also be prepared.

3.2.3 Detailed information about the sources of water-supply, its location and if by wells, the number of such wells, the population served by each, the distance people have to travel to fetch water (water samples may also be sent to the nearest public health laboratory for examination to find out its fitness for drinking purposes). Disposal of waste water, disposal of human and cattle excreta and existence of manure pits should also be gathered.

3.2.4 The following information is also necessary :—

(1) Rainfall—annual average, and maximum so far experienced.

(2) Temperature:

(a) Summer—maximum
—minimum

(b) Winter—maximum
—minimum

(3) Climate—whether humid or arid.

(4) Nature of soil—sandy, alluvial, clayey, black cotton, laterite, rocky, etc.

(5) Suitability of local soil for:

(a) making bricks;

(b) constructing mud walls

(6) Available local material, such as burnt bricks, stones, sand, timber, roofing tiles, thatch, bamboos, lime stone, lime, reed, etc.

(7) Availability of skilled labour, such as masons, carpenters, blacksmiths and their wages.

3.3 Housing Patterns

3.3.1 In rural areas land is generally not scarce and expensive; hence single storeyed construction is desirable. the house can be in 'row', semi-detached or detached. Row houses are economical in land use and save on cost of common walls and services like roads, water supply, drainage and electricity, but present difficulties in regard to keeping of cattle which have to be housed in such a case, in the front courtyard which is not recommended from hygienic considerations. Alternatively the provision of back service lanes could provide a possible solution for taking the cattle to the back courtyard. The provision of back lanes also is not desirable as they remain dirty and unhygienic. Row houses should, therefore, be adopted for persons who do not own cattle, such as artisans and non-agricultural labourers.

3.3.2 Detached houses require too much land and are not economical except for the small well-to-do class. Therefore, generally semi-detached houses with back to back plots avoiding service lanes are suitable for our villages. This arrangement also results in better security for the cattle in the rear courtyard and provides greater scope and flexibility for further expansion.

3.4 Density of Housing

3.4.1 In planning a village a gross density of about 25 to 38 houses per hectare should be aimed at. In the village where sufficiently large area of land is available, the planner may be tempted to go in for a thinner density, but the advantages of a sprawling village with larger house plots, wide streets and extensive open areas must be carefully weighed against the disadvantage of longer run of streets, drains and electric lines to be provided for and maintained.

3.5 Size of Plots

3.5.1 The size and proportions of a house plot is a matter which should receive the consideration of the planner. The width of the plot for a semi-detached house should be such as would allow for a side passage of sufficient width for the cattle, etc, to the backyard.

The depth of the plot should be sufficient as would permit reasonable distance between the cattle-shed and the living rooms, besides accommodating cattle-shed fodder store and a spacious back courtyard. The back courtyard is an essential adjunct to the house as a great number of activities of life are carried out in the open, under the shade of a tree, for many months of the year. For these reasons a depth of 24 to 27 m. is considered desirable, though in areas where land is scarce, lesser depth may have to be adopted. For semi-detached house, a plot size of 9 m × 24 m. and for row type house a plot size of 9 m × 18 m may be adopted subject to variations depending on the availability of land. Plot size will also be governed by the occupational requirements of the inhabitants.

3.6 Open Spaces

3.6.1 An amenity which is often lacking in villages is the availability of open spaces for children to play who are hence obliged to play in dirty streets and odd places. For proper physical as well as mental development of children it is very essential to provide adequate open spaces, dispersed in different parts of the village, for their play and games. Open areas are also required for various other common purposes, such as social gatherings, fairs and 'melas'. The village square which is the meeting place for both children and adults should be centrally located and planted with shady trees. It is recommended that about 1·2 hectares of open space should be provided for a village having 200 houses. The community buildings may be grouped on one side of the open space so that open space could have multiple uses.

3.6.2 Space for manure and compost pits should be provided at the fringe of the village keeping in view the prevalent wind direction so that no offensive smells reach the houses.

3.7 Pattern and Width of Roads and Streets

3.7.1 An important aspect of village planning is the pattern and width of roads and streets. The pattern of streets depends upon the topography and other local features, while the width of the streets is determined by considerations of intensity and nature of traffic, space required for services and adequacy of lighting and ventilation for the structures abutting on the streets. Ordinarily the plying of bullock carts is the only vehicular traffic expected on most of the village streets. The street width should, therefore, be adequate for two loaded bullock carts to cross each other without any hindrance. Some allowance must also be made for the space that may be taken up on the streets for the running of drains. A minimum width of 4·5 m. may be allowed for local streets and 9 m for streets passing through shopping centres or carrying through traffic to main streets and surrounding villages. It should be remembered that too many wide streets inside a village can be a handicap, when it comes to paving, lighting, cleaning and drainage. Adequate provision of open space for parking of bullock carts should also be made, in order that streets may not get obstructed by parked carts.

3.7.2 Road widths should generally conform to the following standards:

(1) Main roads from 12 to 18 m. wide, the latter width to be adopted in those cases in which the road is a through artery between the main villages or towns.

(2) Main streets at least 9 m. wide so as to have two lanes of traffic and side drains.

(3) Small streets to be at least 4·5 m. wide.

(4) Blind lanes should not be encouraged.

3.8 Typical Layouts

3.8.1 Typical layouts of villages incorporating the above principles have been given in Chapter 16

4 Re-Development of Existing Villages

4.1 Planning Approach

Village re-development plans should be prepared in such a way as to meet the requirements, of the particular village adequately and providing for changes that are considered desirable for the welfare of the village as a whole, even if it means radical changes in the way of life of the villagers, sometimes. A study of the existing socio-economic conditions in the village, and an understanding of the difficulties with the present living standards and future housing needs are necessary for sound planning. Regional influences like proximity of cities, transportation facilities and avtilability of electric power, etc., should be considered and due allowance made for the influence of all these factors on the housing requirements. Other developments like mechanical farming and installation of tube-wells should also be kept in view from the point of view of increased agricultural production.

4.1.2 It should also be remembered that in replanning an existing village, the planning standards will have to be suitably lowered to make the development work practical and economical.

4.1.3. As part of the redevelopment plan, it is recommended that provision be made for means to provide additional sources of income to the villagers in order to strengthen the economic possibilities for the work of reconstruction.

4.2 Surveys

4.2.1 When an existing village is to be redeveloped the socio-economic, physical and engineering surveys should be carried out as has been explained in Chapters 2 & 3.

4.3 Village Layout

4.3.1 The layout should be prepared in consultation with the villagers, taking into consideration the prevalent socio-economic and physical conditions. The layout plan should be so devised as to enable the villagers to remodel the village sector by sector. While preparing the layout, all efforts should be made to preserve the existing pucca houses, shady trees, places of worship and wells.

4.3.2 The first step in the preparation of a layout plan is to mark a tentative pattern of internal road system without radically changing the existing road pattern and having to demolish a good number of houses.

4.3.3 Next a sector wise replanning should be carried out. All pucca houses and kutcha houses in good condition in these sectors should be left undisturbed as far as possible. A list of houses which have to be shifted in clearing the congested areas, in widening roads, in the creation of open spaces and in giving proper access to other houses, should be prepared. Land required for these displaced families should be worked out and the possibility of rehousing such families in land as near as possible to their old plots should be examined.

4.3.4 Houses which are retained in the congested areas and have small plots should be given more land so as to bring them to the requisite standard. While clearing congested areas a maximum density of 45 houses per hectare may be allowed.

4.3.5 The village should be given the shortest possible access from the main road serving that area and the width of such a road should be 12 m, if possible. The width of streets may be about 3 m and that of main roads of village 6 m if wider roads are impracticable.

4.3.6 Site for community facilities should be provided as has been explained in Chapter 3.

4.4 Implementation of Re-development Plan

4.4.1 First of all the village layout plan should be explained to the villagers by the Block Development Officer assisted by some technical staff, as it will be difficult for the villagers to understand the full implications of the proposals. Great care and patience has to be exercised in this respect. The best and most simple method is to take the villagers around the village and explain to them the various changes suggested in the plan at each place. If the villagers do not agree to some proposals and suggest some alterations, then the plan with all such suggestions should be sent back to State Rural Housing Cells for their consideration. The decision or the revised plan should again be explained to villagers. After the plan has been accepted by the villagers, the B.D.O. assisted by the Overseer should chalk out a programme for the rebuilding of the village in stages.

4.4.2 It is difficult to lay down order of priorities for the implementation of the redevelopment plan. Normally the villagers would like to build their houses first before doing any work for the community. However, it would be better if the roads and drains could be given first priority; housing could be taken up next and other community works after houses in bad condition have been replaced.

4.4.3 In the housing programme those persons whose house locations are not affected by the redevelopment plan proposals, could start rebuilding first; next persons who have to build houses at new site, and last of all, those persons who have been allotted land left vacant by families who are allotted new sites. The shifting of people from their original sites will pose a difficult problem as people have very deeprooted sentiments about their houses and land. With proper approach and understanding these people can be convinced and if that does not work, they should be left undisturbed; after sometime, when they find other people building their new houses, they may change their minds.

4.4.4 The scheme will succeed better in a village where consolidation of land-holdings has been completed as in such a village a substantial area of land will be left at the fringe of residential areas for expansion purposes. This land usually is vested with the village Panchayat and can be easily utilized for housing persons displaced from congested areas.

4.5 Typical Re-development Plans

4.5.1 Typical re-development plans incorporating the principles outlined above have been given in Chapter 16.

21 NBO—4.

5 Improvement of Existing Houses

5.1 Major Defects in Existing Houses

5.1.1 Village houses are generally dark, damp, ill-ventilated and insanitary. The roof is low and built with flimsy materials, without adequate slopes. The renewal of mud plaster every year is often neglected and the walls are in a state of decay. Windows are conspicuous by their absence. The floor level is sometimes even below the adjoining ground level. The waste water from the kitchen is allowed to accumulate near the house and breeds mosquitoes. Human beings and cows, buffaloes, bullocks and goats live together in close proximity.

5.1.2 There is a lot of scope for improvement of existing houses in villages, as entirely new houses are not within the financial capacity of the villagers. The Village Housing Projects Scheme also lays considerable emphasis on this aspect and makes provision for the grant of loan for effecting improvements to existing houses.

5.2 Suggested Improvements

5.2.1 (a) The floor level of the house should be raised 30 cm above the adjoining ground.

(b) Windows should be provided for adequate light and ventilation.

(c) Roof height should be raised to provide 2·0 m clear headway.

(d) The roof should be laid with treated thatch or country tiles. The process of treatment of thatch has been given in Chapter 8.

(e) The walls should be plastered with water-proof mud plaster as described in Chapter 8.

(f) Waste water from kitchen and bath should be utilized for vegetable garden.

(g) A separate cattle shed should be provided at the rear of the house.

(h) A sanitary type latrine should be provided in the house.

5.2.2. Some improvements which can be carried out in a typical rural house at a small cost are indicated in the figure showing the house before and after the treatment.

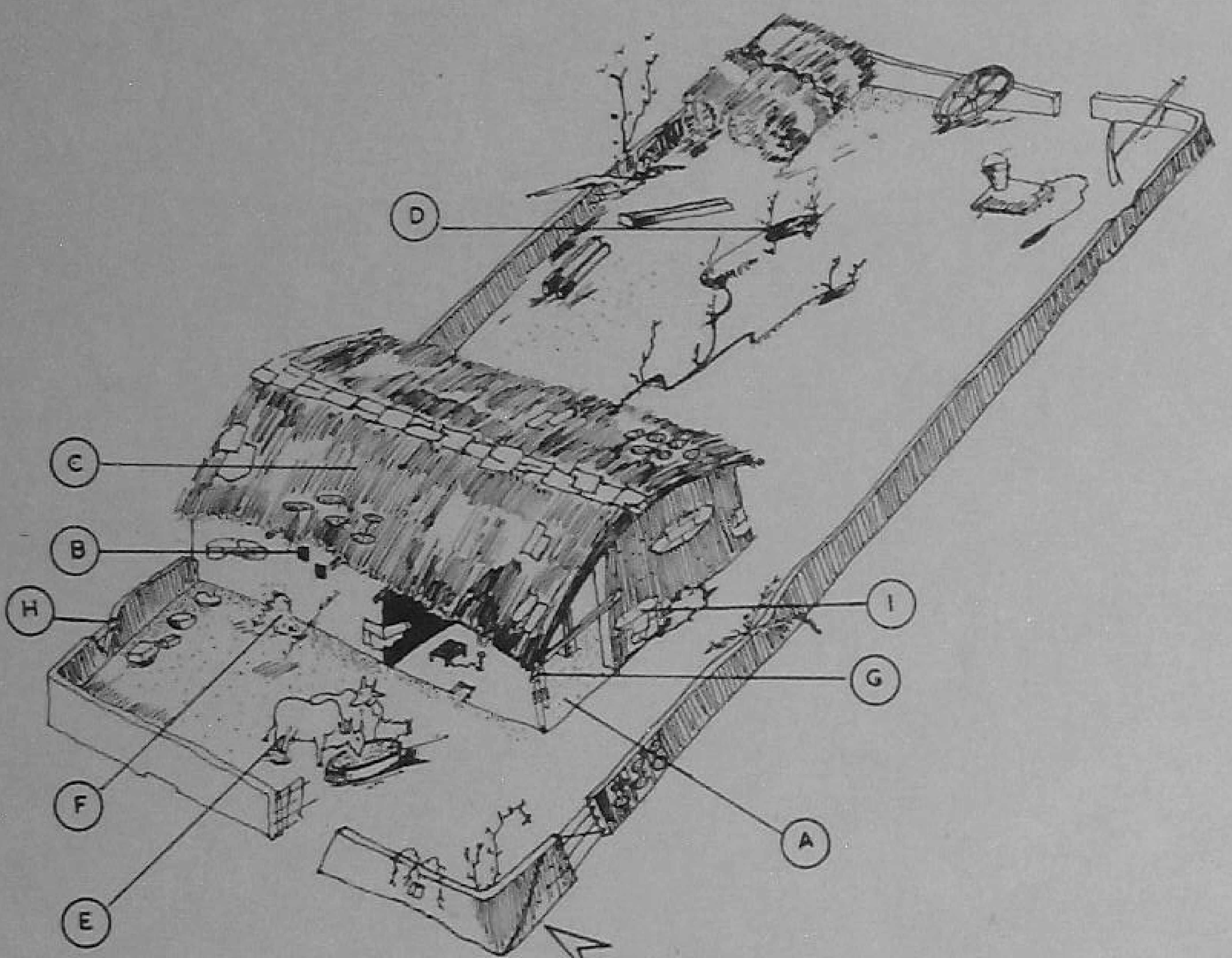
FIG. I

AS EXISTS TODAY

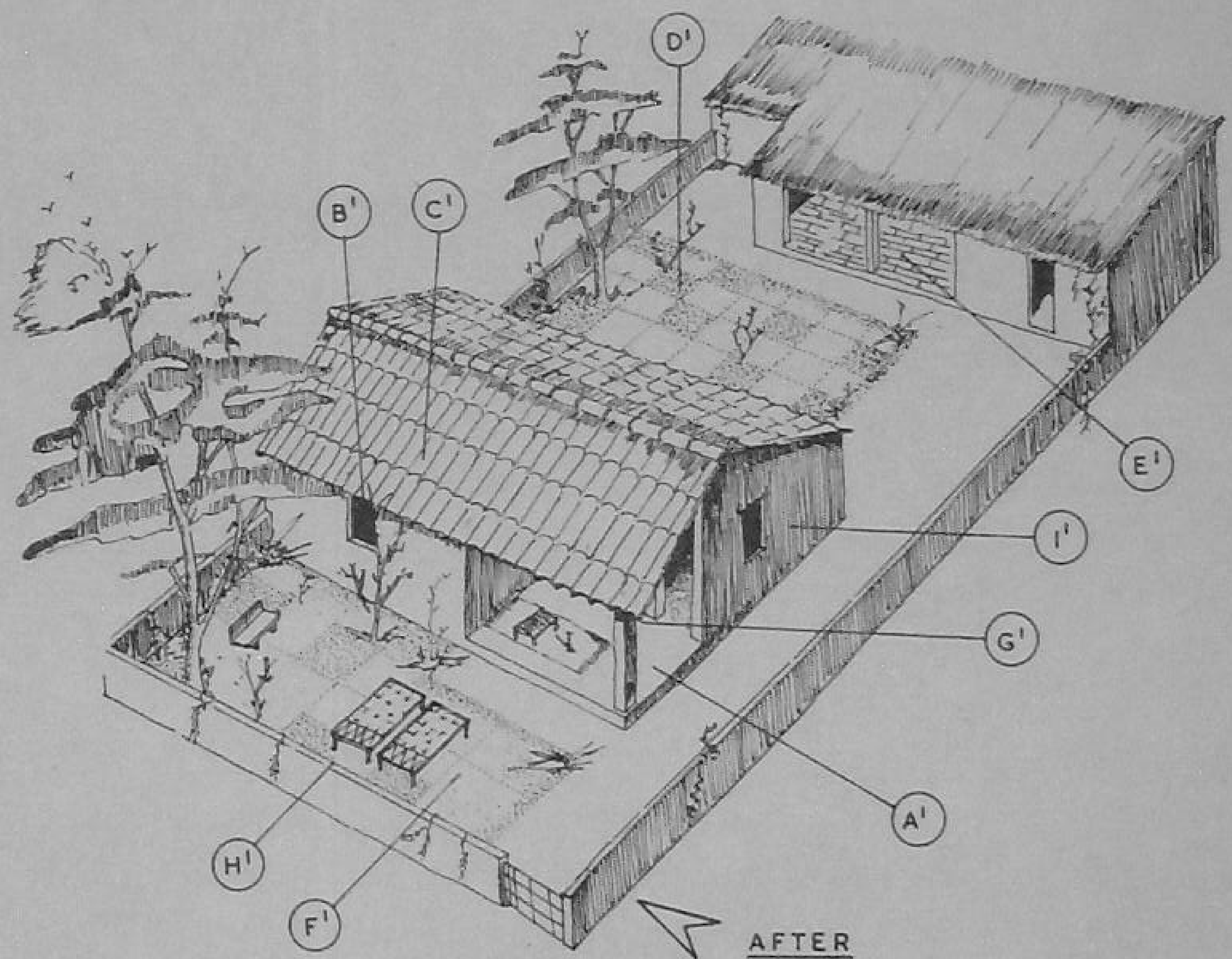
- (A) FLOOR LEVEL BELOW THE ADJOINING GROUND
- (B) SMALL HOLES INSTEAD OF WINDOWS
- (C) ROOF WITH THATCH ETC. WITHOUT PROPER SLOPE
- (D) CONTAMINATION OF THE GROUND WITH KITCHEN & BATH WATER
- (E) DOMESTIC ANIMALS TIED CLOSE TO THE HOUSE
- (F) COURTYARD SPOILED WITH RUBBISH
- (G) VERY LOW ROOF HEIGHT
- (H) IRREGULAR COMPOUND WALL
- (I) MUD PLASTER IN DISREPAIR

IMPROVEMENTS

- (A') FLOOR LEVEL RAISED 0.3 METRE ABOVE THE ADJOINING GROUND
- (B') WINDOWS PROVIDED FOR ADEQUATE LIGHT AND VENTILATION
- (C') IMPROVED ROOF WITH COUNTRY TILES ETC. LAID TO PROPER SLOPE
- (D') WASTE WATER FROM KITCHEN & BATH UTILISED FOR VEGITABLE GARDEN
- (E') CATTLE-SHED AS FAR AWAY AS POSSIBLE FROM THE HOUSE
- (F') COURTYARD KEPT CLEAN TIDY AND PLANTED WITH TREES
- (G') ROOF HEIGHT RAISED TO PROVIDE 2 m HEADWAY
- (H') REGULAR COMPOUND WALL
- (I') WATER PROOF MUD PLASTER



BEFORE



AFTER

A TYPICAL VILLAGE HOUSE

(BEFORE AND AFTER IMPROVEMENTS)

6 Planning of Rural Houses

6.1 Housing Requirements

6.1.1 While in an urban area a one-roomed house has been accepted as the minimum for the time being, in rural areas, due to differing conditions, generally a two-roomed house (or a room and a living verandah) should be considered as the minimum. Village economy is based more on 'kind' than on 'cash' and therefore the need for space required for storage of articles, such as grain, pulses, oil, cotton, fuel, etc., for household use is much more in villages. As such, the area of living space (including verandah) should, generally, be not less than 20 sq. m. In addition, there should be a kitchen (verandah or room), a latrine and a back courtyard. For bathing and washing purposes there could be a small paved platform in the back courtyard. If, due to economic stringency some villagers cannot afford a two-roomed house to begin with, and only a one-roomed house is provided, there should be provision in the house design for the addition of another room subsequently.

6.1.2 In India, generally, the climate in many regions is such, that it is more comfortable and healthy for the people to live and work outside the house in the open or under a tree, for many months during a year. A courtyard, therefore, for this purpose is a very essential adjunct to a village house and its design and layout should receive adequate attention. A courtyard at the back of a house affords greater privacy and is more useful than one in front, particularly from the view point of the needs of the womenfolk. Wherever possible, however, it is desirable to also have a front courtyard which could be smaller than the one at the back for use by the men-folk.

6.1.3 Apart from the space needed for human habitation there should be separate accommodation for cattle, in the form of a shed in the back courtyard, and for storage of fodder, agricultural implements and agricultural produce. Requirement of space for these purposes would vary with individuals. In case of artisans, such as weavers, carpenters, blacksmiths, shoe-makers and cobblers, etc., provision for space shall have to be made in the house design to meet the special needs of their trade. Similarly a shopkeeper may also require a shop as a part of his house. Requirements of villagers with different economic standards and vocations have to be studied in detail so as to be able to evolve a variety of house designs. As a general rule, the various house designs should include provision for future expansion. The house should afford shelter as well as privacy. Broadly speaking the villagers could be classified as under for the purpose of standard type design:—

(a) Farmers with large land holdings.

(b) Farmers with small land holdings,

(c) Artisans with different trades.

(d) Shopkeepers,

(e) Landless labour and the service community.

6.2 Light and Ventilation

6.2.1 There are some aspects, in which a present rural house is particularly defective. It is a common experience that villagers do not provide windows of adequate size with the result that rooms are ill-ventilated and dark. Even the doors, quite often, are of inadequate height with the result that the inhabitants have to stoop down for going in and out. For a house to be healthy and comfortable, it is essential that doors and windows should be of reasonable size. Minimum clear height of doors should be 1·8 m. Minimum area of windows may vary between 8 per cent and 10 per cent of the room area depending upon climate. In case of hot and arid regions, where it is necessary to exclude heat and glare from the rooms during the summer, comparatively lesser window area would suffice, while in case of hot and humid regions greater window area is needed for comfort. Window in the kitchen should be of adequate size and so placed that there is sufficient light at the cooking place. In case of store rooms not intended for human habitation, need for ligthing and ventilation is generally much less than that for living rooms. The villagers ordinarily provide inadequate ventilation and lighting on considerations of economy and security. Windows should, therefore, be designed with an eye on these considerations consistent with needs of health and comfort.

6.2.2 Another common defect in a village house at present is the smoky kitchen, because of lack of proper chullah and chimney. Quite often, cooking is done in the living room itself. From consderations of health, it is essential to have a separate place for cooking, with an efficient arrangement for outlet of smoke. The design of a smokeless chulla has been given in Chapter 13. Provision of adequate shelf space in the kitchen is also important.

6.3. House Design

6.3.1 A village housing programme will not be successful if the types of houses to be recommended to the villagers do not keep in accordance with their customs and traditions. The designer has to be aware of this fact and should be able to combine, in a manner acceptable to the villagers, both tradition and the minimum requirements of housing and health standards.

6.3.2 It is, therefore, essential that village housing design should be evolved on sound principles after careful study of the living habits and preferences of the people who will reside in them. For this purpose the task of evolving house designs should be preceded by proper investigation so as to obtain an overall picture of the housing conditions, architectural, characteristics and living habits of the people. The results of this investigation should be supplemented with the general information obtained from the socio-economic and physical surveys.

6.3.3 It is recommended, especially when designers are not at all familier with the housing condition in a particular village, to conduct a sample survey of a few representative houses. This survey should be made by means of sketches showing:

(i) Shape, size and location of plot in relation to entire village, indicating group of houses where the unit under investigation is located.

(ii) Orientation of the plot.

(iii) Dimensions of various rooms, position and size of openings, niches, shelves, etc.

(iv) Prevailing position of furniture and other utility articles, etc.

(v) Detailed study of any decorative feature or other features of special interest.

(vi) Landscaping, courtyard and arrangements inside.

(vii) Position and type of bathrooms and latrines.

Experience has demonstrated that this type of investigation enables the designer to have a better understanding of rural housing, thus making his designs more realistic and adequate.

6.3.4 India is a subcontinent with wide variation in climate, rainfall, topography, nature of soil, local resources, social customs, and economic conditions, etc. House design, construction and planning techniques, therefore, differ from place to place and it is undesirable to lay down any uniform standards for the country as a whole. However, some broad aspects of planning are discussed below:

(1) Architecture of houses should be simple and functional and buildings should harmonise with the rural surroundings.

(2) In order to make the houses reasonably comfortable, adequate attention should be paid to climatology and orientation. In hot and arid regions the rooms should be so placed that during summer there is minimum of heat gain through the walls and openings in walls should be restricted. In hot and humid regions, houses should be orientated with reference to the direction of the prevailing winds and living rooms should be designed to have adequate cross-ventilation.

(3) Cattle shed and latrine should be located so as to be at some distance from the main house; and a fair sized courtyard which is an essential adjunct to a rural house should be provided.

(4) While providing for reasonable lighting and ventilation to the various parts of the house, the need for restricting the size of windows and ventilators from the point of view of economy and security should not be lost sight of.

(5) The construction of houses should normally be such as to have a life of 15 to 20 years.

(6) For ease in construction and economy in cost, as far as prossible, bends, corners and offsets should be avoided and in sloping roof there should not be any valley. With roofing materials and skill generally available in villages, it is difficult to make the valley leak-proof. For similar reasons house should be designed to have rooms with small spans consistent with other requirements.

(7) The house design should provide for future expansion, particularly in case of small houses, so that later on when the need of the family increases or means improve, it should be possible for the villager to enlarge his house.

6.4 Typical House Designs

6.4.1 Typical designs for one, two and three roomed houses incorporating the above principles have been given in Chapter 16. The designs cover all regions of the country.

7 Community Buildings

7.1. Introduction

7.1.1 Community buildings are essential to cater to various social, medical, educational and other needs of the villagers. In this chapter typical plans of various types of buildings have been given for guidance.

7.2 Primary Health Centre

7.2.1 The purpose of a clinic or a health unit is to provide medical advice and aid to varying groups of persons as part of full public health service. At times a number of units for different purposes are grouped together for simplification of administration and to share certain common services. The main and more useful units that are so combined are general medical practitioner units, ante-natal and post-natal units, child welfare units, etc. When these units are combined for prevention, detection, cure and health education, the combined unit is known as a Health Centre.

7.2.2 The Community Development Programme envisages an integrated pattern of health care for rural areas, combining both the preventive and curative services with greater emphasis on the prevention aspect. This programme of health care is to be implemented through primary health centres in rural areas.

7.2.3 There are 5261 Community Development Blocks* in the country which have been established under the Community Development Programme. Each block covers about 100 villages and serves a population of 80,000 to 100,000. For the purpose of providing health facilities each community development block is visualised to have ultimately 3 Primary Health Centres. For every 3 Primary Health Centres, it is proposed to have one Secondary Health Centre to provide general medical facilities and special services.

7.2.4 Due to paucity of funds and non-availability of trained personnel, it is not possible at present to implement the above scheme in full. As such every Community Development Block will have 1 Primary Health Centre and 3 Sub-Centres to start with.

7.2.5 The basic services that will radiate from the Primary health centres and sub-centres are

1. Medical care;
2. Maternal and child welfare including family planning;
3. School health;
4. Health education;
5. Environmental sanitation;
6. Control of communicable diseases with priority for malaria; and
7. Collection of vital statistics.

7.2.6 *Space Requirements*—The Health Centre building should provide accommodation for the following:

1. Waiting;
2. Multi-purpose room (office, record and enquiry);
3. Dispensing of medicines;
4. Examination and consultation;
5. Dressings;
6. Maternal and child health;
7. Storage;
8. Family Planning;
9. Indoor ward;
10. Duty room;
11. Ancillary services, like garage, residential accommodation for attendants attending on patients and for staff.

7.2.7 *Landscaping*—Landscaping of the area housing the Health Centre should be pleasing and cheerful. Judicious planting of flowery shrubs, creepers and evergreen trees would enhance the beauty of the surroundings and make it pleasant both for the medical staff and the visitors. The areas where the patients wait should specially be well-treated and looked after.

7.2.8 *Requirements of Site*—Usually the building starts with a certain size, but very soon has additional needs, either because of expansion of needs or because of an increase in the number of people served by the building or because the same people develop new kinds of needs. It is, therefore, advisable to keep a liberal margin for future expansion because acquisition of surrounding land at a later date becomes very difficult. The area of site should be sufficient to house:

(a) Primary Health Centre building together with its ancillary structure.

(b) Open space for demonstration of environmental sanitation, rural latrines, etc.

(c) Staff quarters.

It is suggested that an area of 0.8 to 1.0 hectare should be acquired for the purpose.

7.2.9 *Model Plan*—*Fig.* 1—gives the model plan of a Primary Health Centre for rural areas prepared by the Panel on Health Buildings appointed by the Ministry of Works and Housing, Government of India. For further information, the reader may refer to the "Report on Primary Health Centres in Rural Areas" published by National Buildings Organisation, New Delhi.

7.3 Maternal and Child Health Sub-Centre

7.3.1 Maternal and child health services form the basic foundations of healthful living. It is, therefore, essential that care of the mother and child must receive the highest priority in any programme for the development of a healthy community. This aspect of health-care assumes special importance in rural areas where ignorance, superstitions and lack of knowledge before and after child birth cause good deal of mortality, morbidity and human sufferings.

7.3.2 The Community Development Programme envisages establishment of 3 Maternal and Child Health Sub-Centres under each Primary Health Centre. From these Sub-Centres various health services, particularly ante-natal and post-natal services will radiate into the homes of the people in addition to the services given at the Primary Health Centres.

7.3.3 The basic functions of these sub-centres will be:

1. Ante-natal and post-natal care,
2. Domiciliary midwifery,
3. Home nursing,
4. Guidance on family planning,
5. Health education.

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*As on 1-1-1966

†Figures at the end of chapter.

7.3.4 To carry out the functions stated above, the Sub-Centres are at present staffed by a trained 'dai' or a mid-wife who is supervised in her work by a lady health visitor under the overall charge of the Medical Officer of the Primary Health Centre.

7.3.5 The Health Survey and Planning Committee has recommended upgrading of these Sub-Centres and has suggested a three-phased programme of recruitment of staff so that in the final phase the following staff will be in position:

Medical Officer	1
Public Health Nurse	1
Auxiliary Health Worker	1
Mid-wives	3
Pharmacist	1

The Sub-Centre will ultimately also have an indoor unit of 4 beds.

7.3.6 It will not be possible for a long time to come to provide facilities on the scale envisaged above. The building, therefore, will be constructed for the present requirement, but the land should be acquired for the ultimate requirements.

7.3.7 *Area of Site*—In considering requirements of land, it is to be borne in mind that the Sub-Centres in course of time would be up-graded to the level of Primary Health Centres when funds and personnel become available. To meet this eventuality it is advisable to acquire an area of about 0.8 hectare as recommended for Primary Health Centres.

In certain cases, it would, however, mean substantial investment in land initially but the money so invested would pay high dividends later; for when the surroundings are all built over it would be difficult to acquire the adjoining piece of land that might be lying vacant at present. Many an expansive or development scheme is handicapped due to shortage of land.

In cases when there is no possibility of the Sub-Centres ever being upgraded to Primary Health Centres, an area of about 0.6 hectare may be required which would be sufficient, to cover the final phase of the Sub-Centre as well as staff quarters.

7.3.8 *Model Plan*—Fig. 2 gives a model plan for Maternal and Child Health Sub-Centre for rural areas. This plan has been recommended by the Panel on Health Buildings appointed by the Ministry of Works & Housing Government of India. Further information may be obtained from "Report on Maternal & Child Health Sub-Centre Buildings in Rural Areas" available from National Buildings Organisation, New Delhi.

7.4 Police Stations & Out Posts

7.4.1 Police stations and out posts are essential for maintenance of law and order in rural areas. A police station is required for a group of villages covering about 130 square kilometres of area. In the police station about 7·5 sq. m. space should be provided for waiting and 9 sq. m. for office and records, etc. There should be separate report room, 'malkhana' and lock ups for males and females. A typical plan of a police post is given in Fig. 3.

7.4.2 For a police out post about 15 sq. m. area should be provided for constable room, 7·5 sq. m. for office room and 5·5 sq. m. for store.

7.5 Post Office

7.5.1 In individual villages the local school teacher runs the post office in a small room. For a group of villages a post office with sub post master's quarter is essential. Fig. 4 shows the design of a post office.

7.6 Primary School

7.6.1 Rural backwardness to a great extent may be attributed to lack of education. Therefore, primary school is a must in every village.

7.6.2 For a primary school the following accommodation should be provided:

1. Class rooms—one class to accommodate 40 students. 0·9 sq. m. area to be provided per student. Minimum area of a room to be 36 sq. m.
2. Multi-purpose room—area about 55 sq. m.
3. Headmaster's room—area about 22 sq. m and staff room.
4. Store—area about 10 sq. m.

7.6.3 *Sanitary Facilities*—The formation of good health habits is an essential objective of education. It is therefore, imperative to provide proper sanitary facilities in the schools. Minimum provision of sanitary facilities should be as follows:

Latrine—1 for 100 students or part thereof.

Urinals—1 for 25 boys or part thereof.
1 for 20 girls or part thereof.

Water taps—1 for 50 students or part thereof.

7.6.4 *Size of Site*—Minimum size should be about 0·6 hectare.

7.6.5 *Travel Distance*—About ½ km.

7.6.6 *Model Plan*—A Plan of a primary school incorporating the above principles is shown in Fig. 5.

7.7 Community Centre

7.7.1 The income level of the villagers is gradually rising with the adoption of improved methods of agriculture and animal husbandry, and the development of secondary sources of livelihood, such as poultry-farming, cottage industries, etc. The growth of civic consciousness and the urge to live better follow close upon economic development. In the initial stage, groups of villagers get together under the shade of a tree and discuss their common problems. As they get drawn more closely together, the need for some sort of a community life is more strongly felt. As a first step towards the fulfilment of this need, a plan for a community centre takes shape, and sooner or later the building is constructed.

7.7.2 A small community centre of the type shown in Fig. 6 & 7 serves as a multi-purpose building. It is used as a hall for holding meetings and social functions, staging of shows, exhibition of handicrafts, etc. It may also be used for imparting adult education as well as training in handicrafts, cottage industries and domestic science. A removable wooden partition may conveniently divide the hall into two parts, one for the men and the other for the women. The building is also meant to contain panchayat records, the community radio, some reading material, educative posters, etc. The store room in conjunction with the spacious verandah can also be used as a dispensary, till a health centre is built for the village.

7.8 Bus stand & Sing Posts

7.8.1 Rural areas are now being served increasingly by bus transport. The villagers converge to the nearest bus stand and wait for the arrival of the bus. For their convenience bus stands of the type shown in Fig. 8 may be constructed at bus stops which serve about 100 passengers daily. The building provides for the seating of about 15 passengers and a small tea stall for serving light refreshments to them. Another small room serves as a

store or a booking office. The utility of the whole arrangement would be considerably enhanced by providing a paved platform under a shady tree near the tea stall. The bus stand should, as far as possible, be located on a loop, in order to keep the main road free from congestion.

7.8.2 Sign posts may be required at bus stands, road junctions, etc. A simple design of a wooden sign post is indicated in the drawing. The lower portion of the post should be treated with hot creosote, before embedding it in the concrete or masonry.

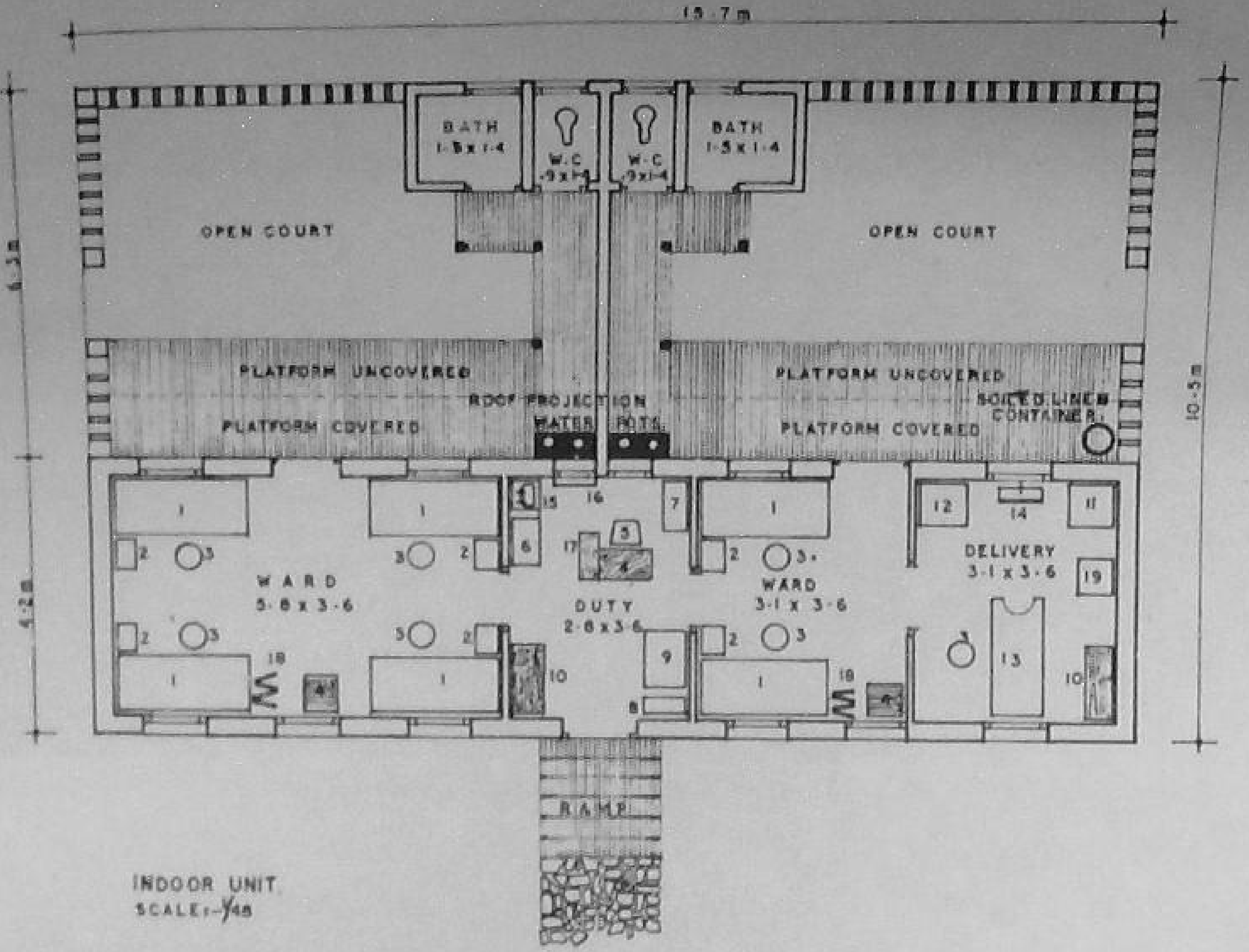
7.9 Co-operative Store

7.9.1 Co-operative effort is the basis of all development programmes in rural areas. It is, therefore, necessary to have a co-operative store in the village. Fig. 9 shows the design of a co-operative store for rural areas.

7.10 Shop Cum Residence

7.10.1 The Village shopkeeper is an indispensable part of the rural community. He is generally well off and can afford to own a two-roomed house with a shop attached to it, of the type shown in Fig. 10.

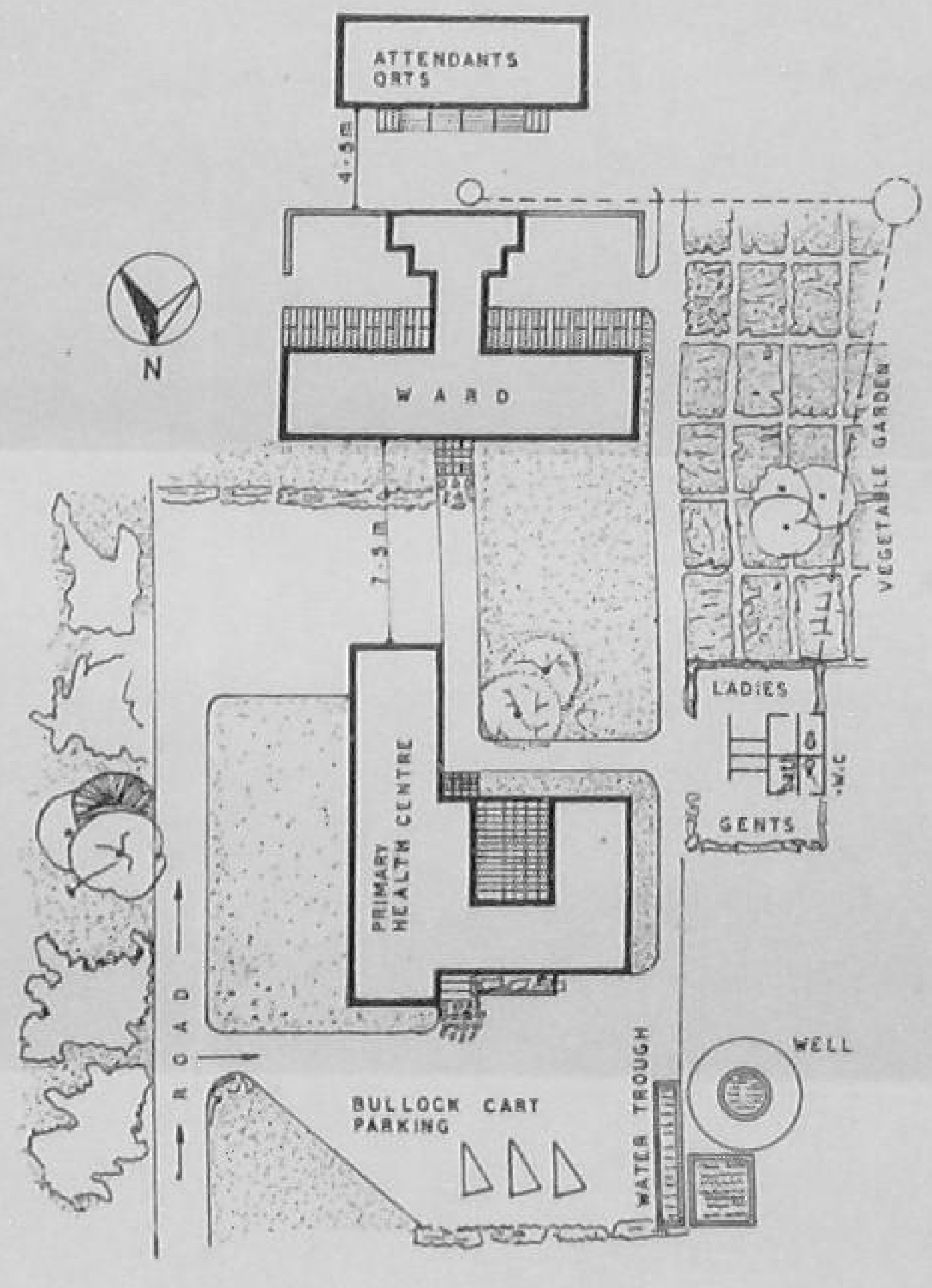
7.10.2 The design provides for the location of the shop in the front facing the road, leaving a 1·25 m. wide passage for independent entry into the house without disturbing the shop. An inner courtyard which separates the shop from the residential unit, provides privacy to the house-hold and also serves as a storage space for sacks, crates, boxes, etc. The residence, consisting of two rooms, kitchen, store, verandah, bath, latrine, and a back courtyard is located behind the shop. The design is suitable for row construction in six to eight units on plots of size 7·5 m × 22·5 m. It is advisable to leave a space of about 4·5 m between the road boundary and the shop, in order to avoid congestion on the road.



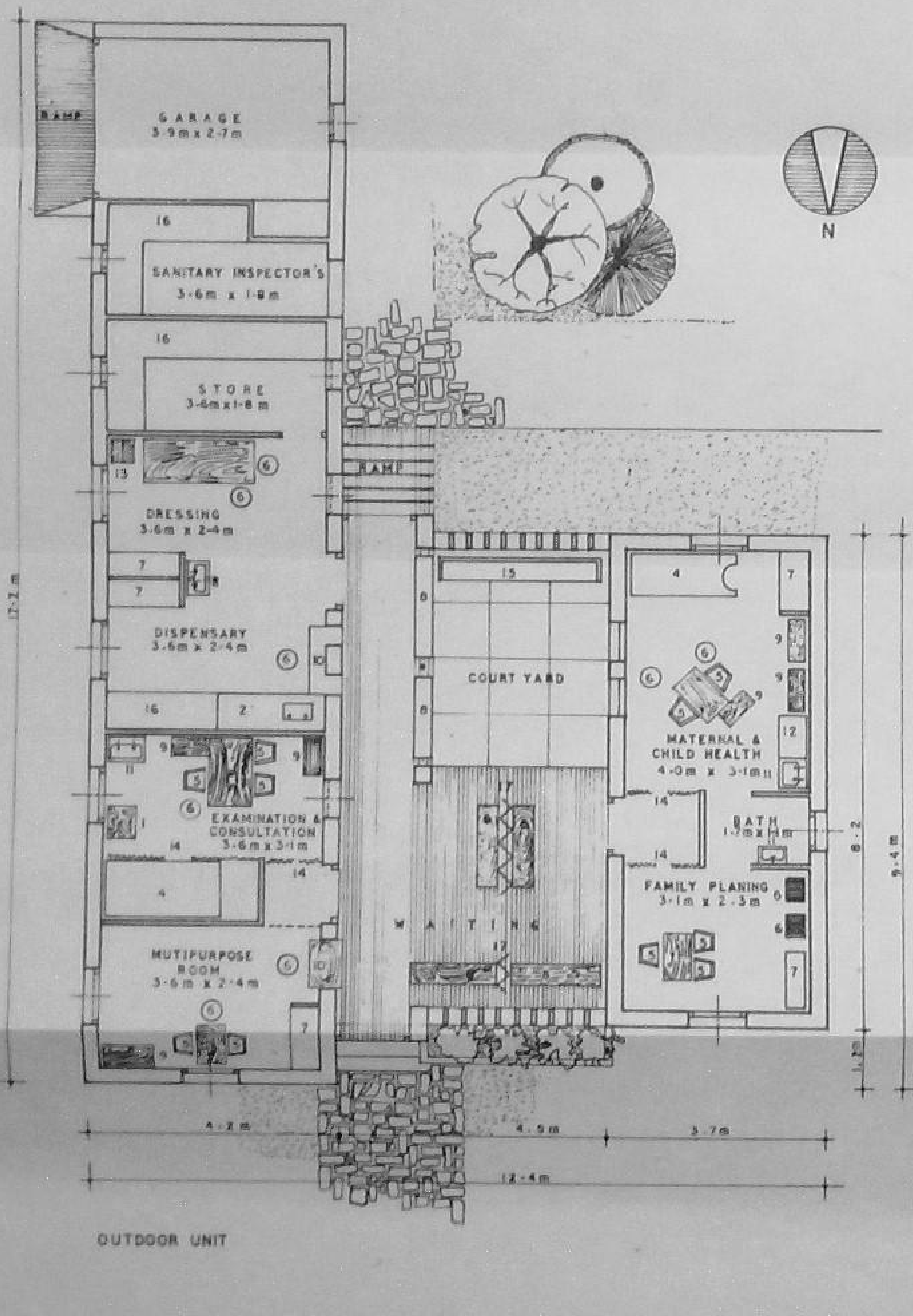
INDOOR UNIT
SCALE 1-1/48

REFERENCES

1. BED.
2. BEDSIDE LOCKER.
3. STOOL
4. TABLE
5. CHAIR
6. FOOD CUPBOARD
7. CUPBOARD FOR MEDICINE.
8. STRETCHER.
9. WHEEL CHAIR.
10. ALMIRAH.
11. TABLE FOR BABY BATH
12. CRADLE.
13. OBSTETRIC TABLE.
14. WASH STAND.
15. WASH BASIN.
16. TOWEL RAIL.
17. SIDE RACK.
18. WOODEN SCREEN.
19. INSTRUMENT TROLLEY



LAYOUT PLAN.



OUTDOOR UNIT

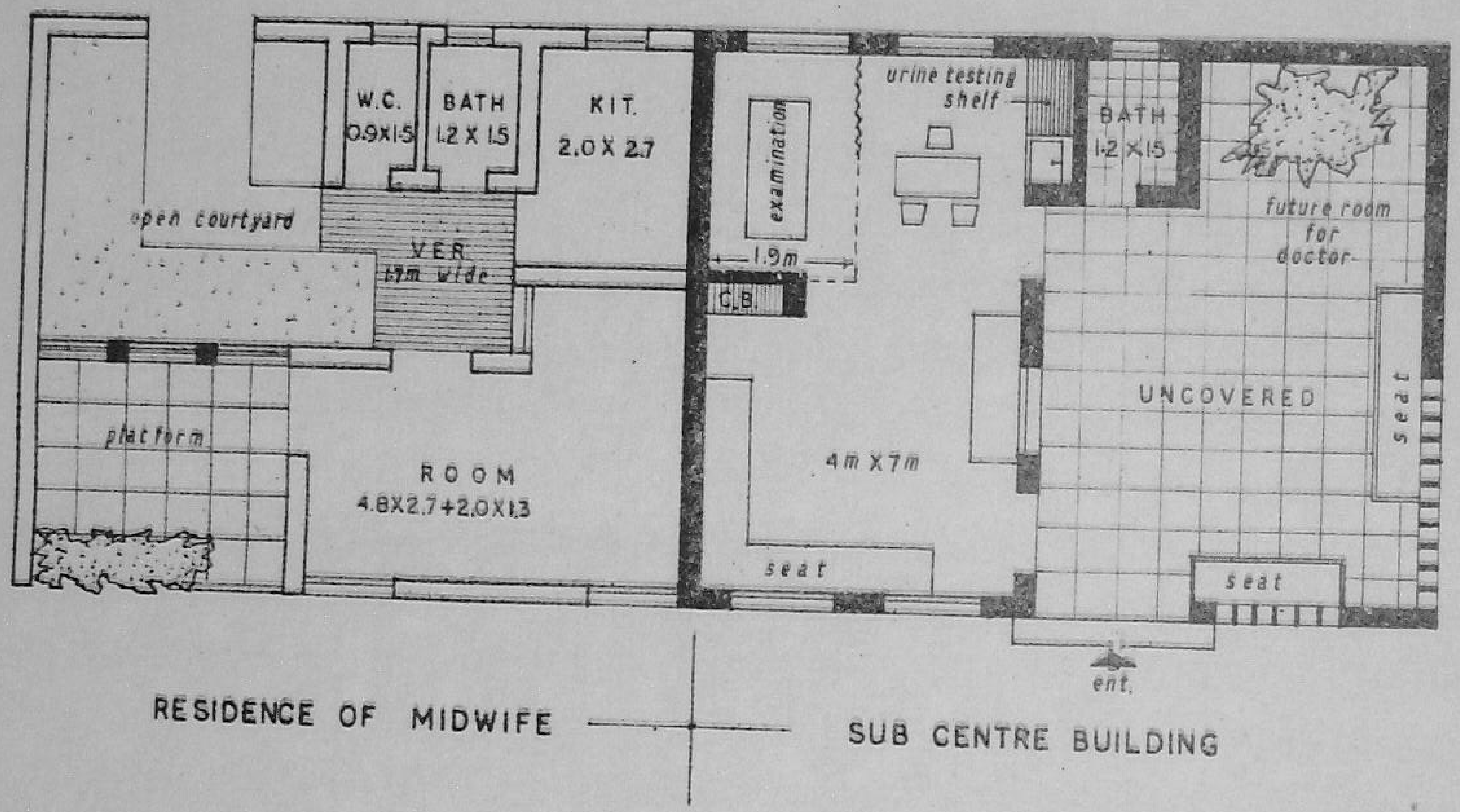
REFERENCES

1. OFFICE TABLE.
2. DISPENSING TABLE.
3. DRSSING TABLE.
4. EXAMINATION TABLE.
5. CHAIR.
6. STOOL.
7. ALMIRAH.
8. BENCH.
9. RACK.
10. COUNTER.
11. WASH BASIN & TOWEL RAIL.
12. URINE TESTING SHELF.
13. DRESSING TROLLEY.
14. CURTAIN ROD
15. SEATS (STONE OR CONCRETE)
16. SHELF
17. WOODEN SCREEN.

MODEL PLAN FOR PRIMARY HEALTH CENTRE

ALL DIMENSIONS ARE IN METRES

FIG 2

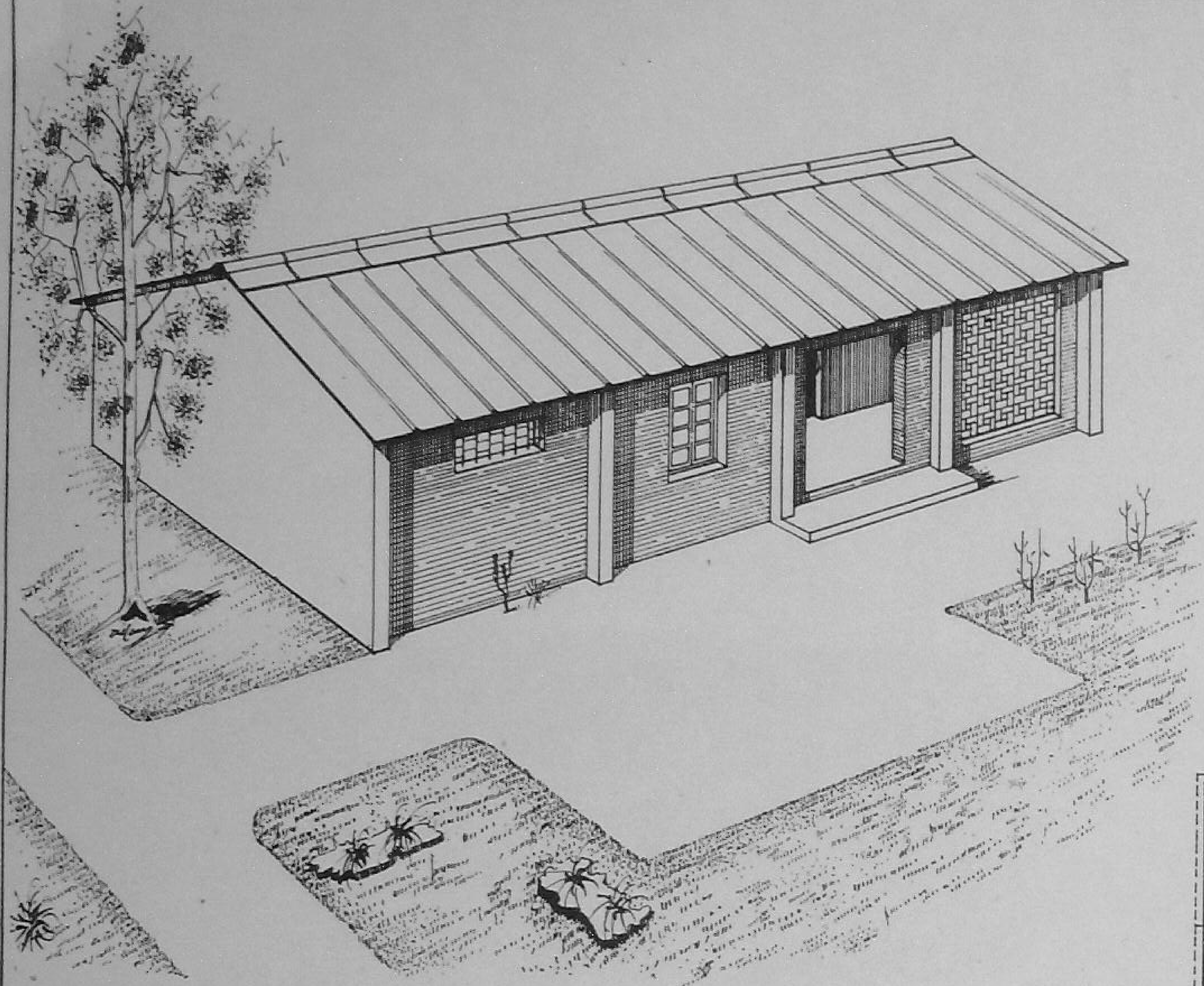


MATERNAL & CHILD HEALTH
SUB-CENTRE
IN RURAL AREAS

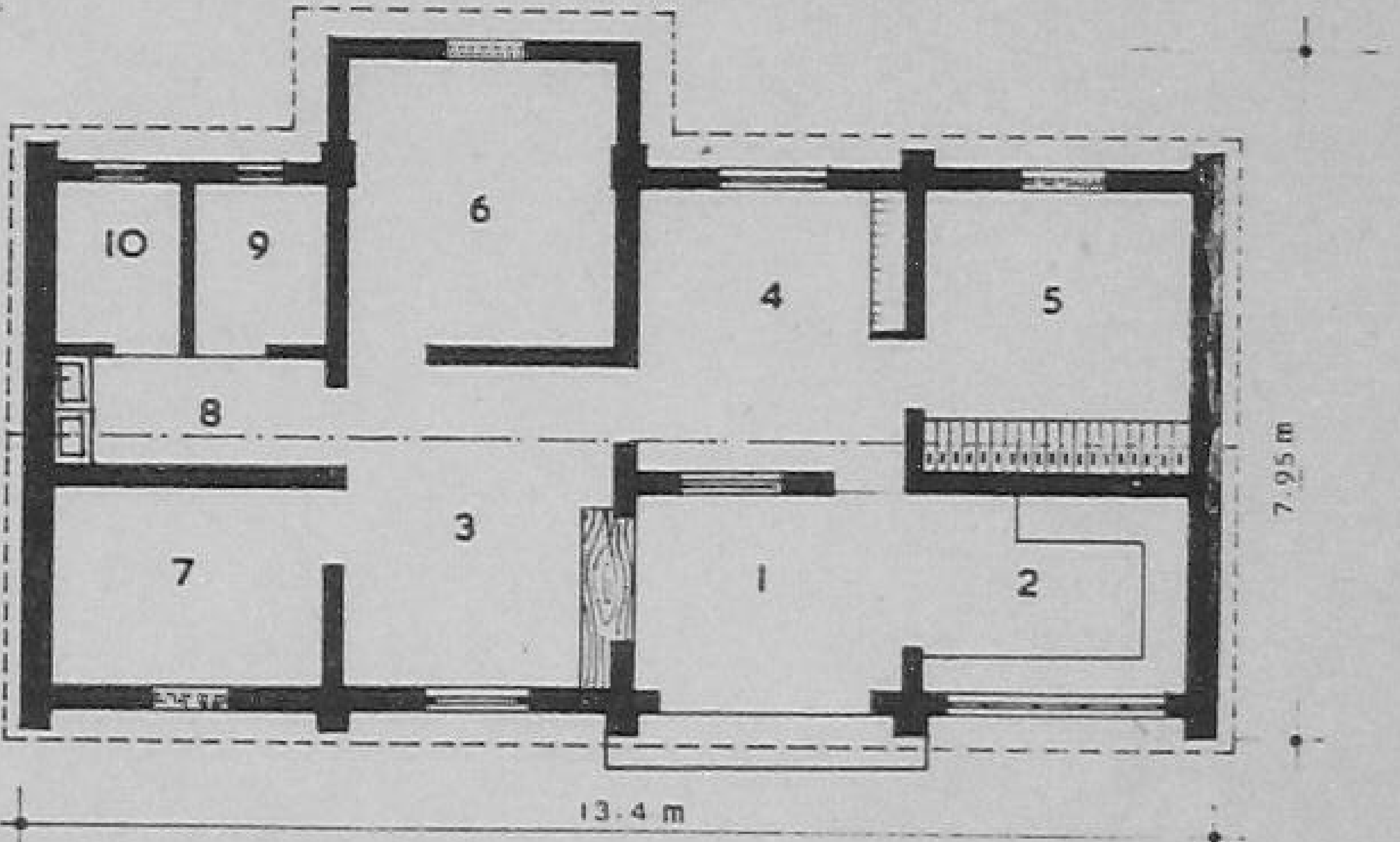
scale 1/96

all dimensions in metres

FIG. 3

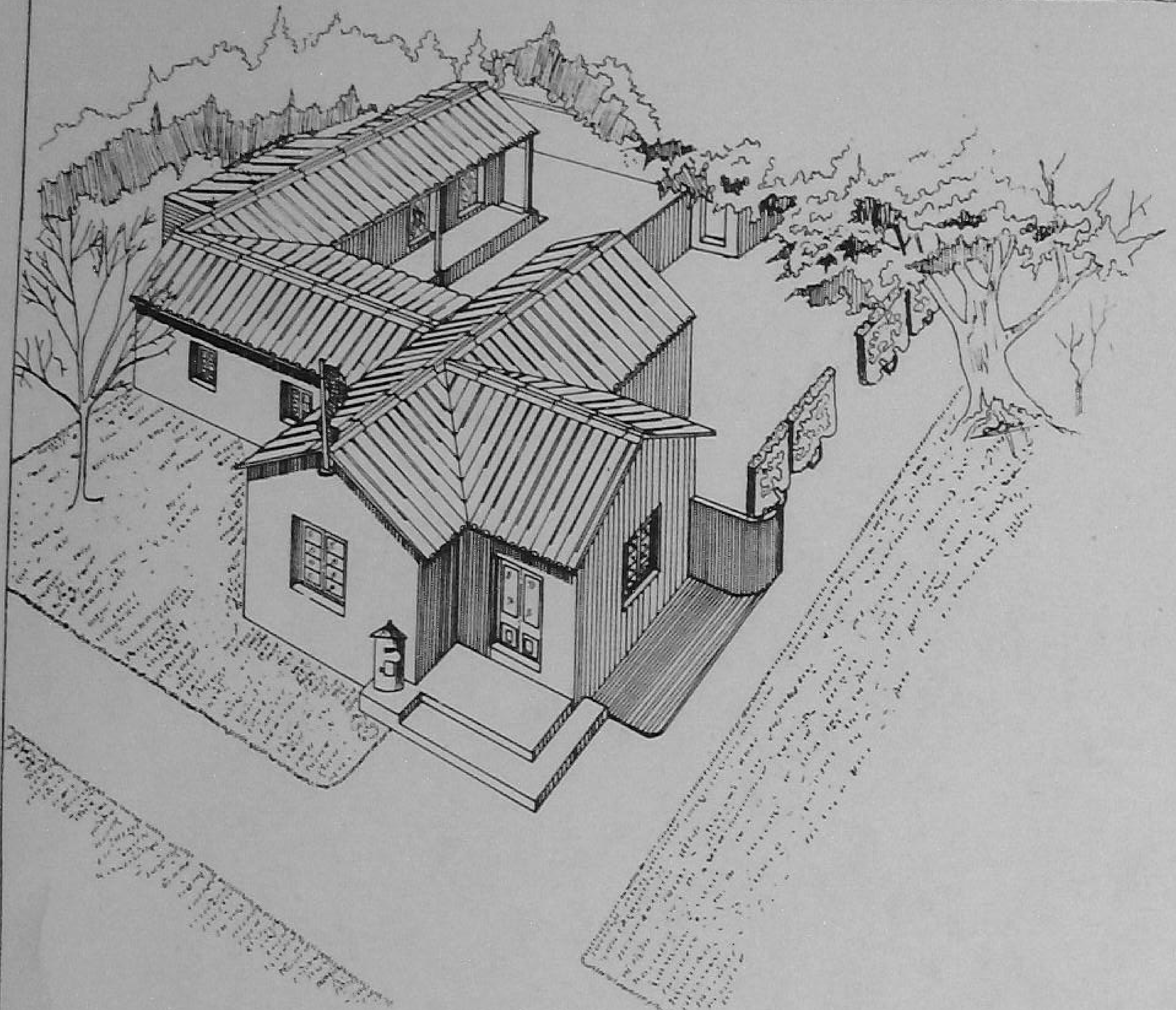


1.	ENTRANCE	3.0m X 2.45m
2.	WAITING	3.0m X 2.45m
3.	REPORT	3.0m X 3.9m
4.	OFFICE	3.0m X 3.1m
5.	MALKHANA	3.0m X 3.15m
6.	LOCK-UP (MALE)	3.0m X 3.2m
7.	LOCK-UP (FEMALE)	2.95m X 2.45m
8.	LOBBY	1.2m WIDE
9.	BATH	1.5m X 1.8m
10.	LATRINE	1.35m X 1.8m

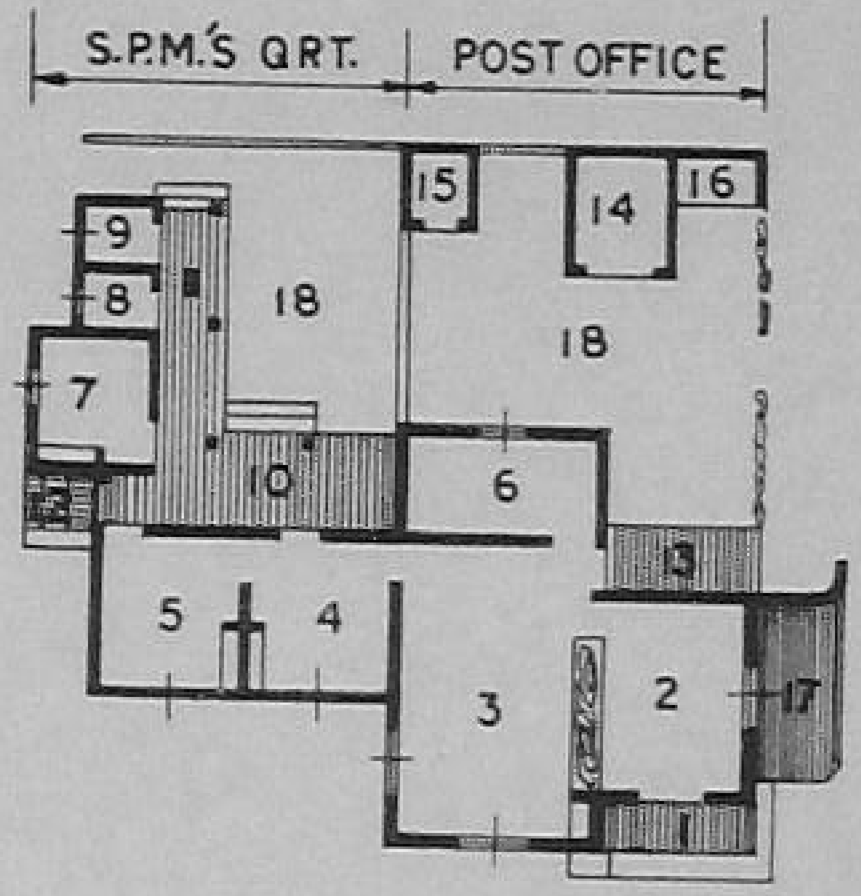


PLAN

A POLICE POST



1	PLATFORM	1.22m x 3.0m
2	PUBLIC SPACE	3.0m x 4.0m
3	POST OFFICE HALL	4.25m x 6.4m
4	ROOM	3.0m x 3.35m
5	ROOM	3.0m x 3.35m
6	STORE	4.25m x 2.15m
7	KITCHEN	2.44m x 2.75m
8	BATH	1.52m x 1.22m
9	LATRINE	1.52m x 1.22m
10	VERANDAH	2.15m WIDE
11	VERANDAH	0.9m WIDE
12	PLATFORM	1.52m x 1.35m
13	PLATFORM	3.9m x 1.83m
14	CART SHED	2.15m x 2.44m
15	LATRINE	1.0m x 1.52m
16	STAFF CYCLES	1.83m x 1.22m
17	PUBLIC CYCLES	
18	OPEN COURT YARD	



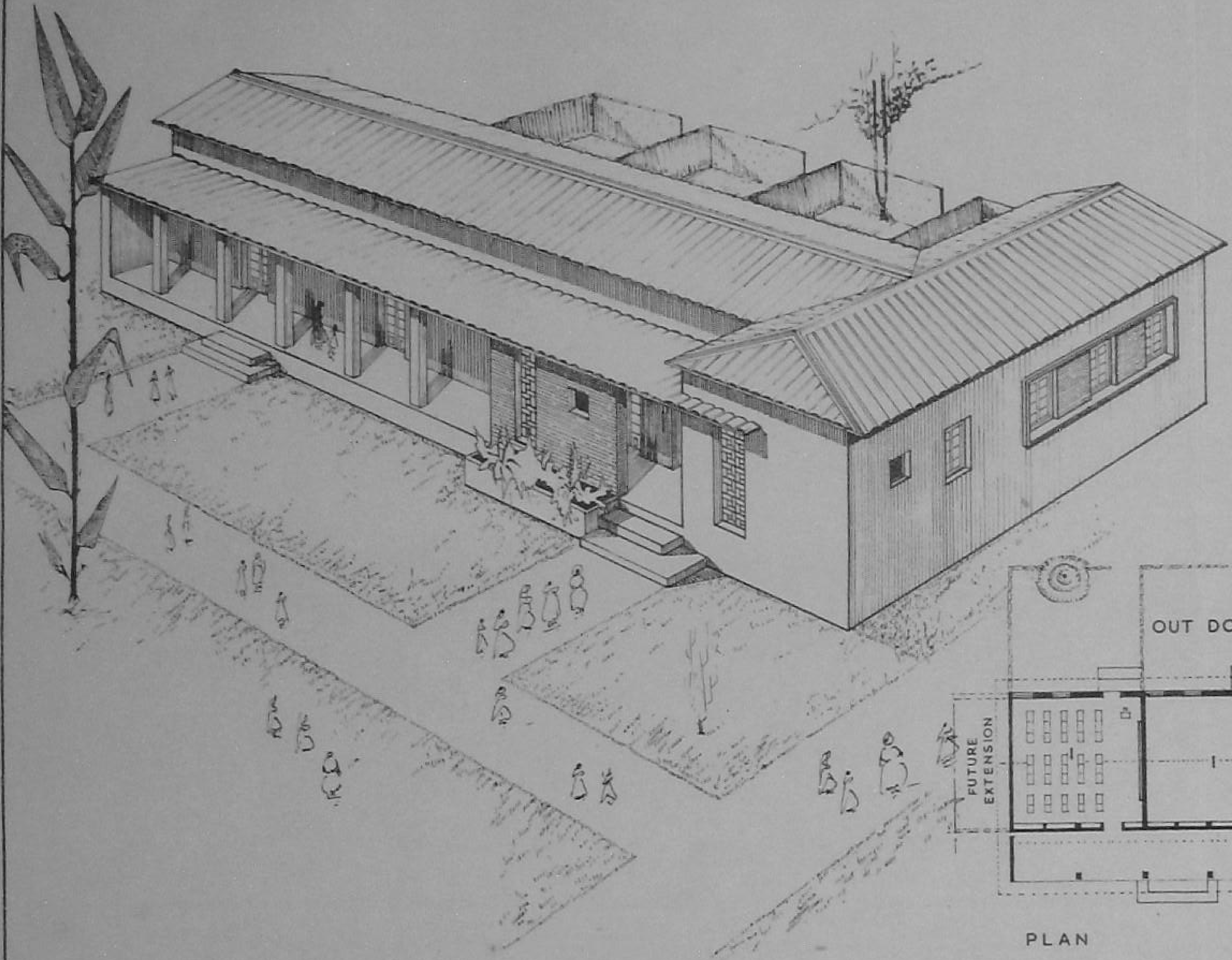
PLAN

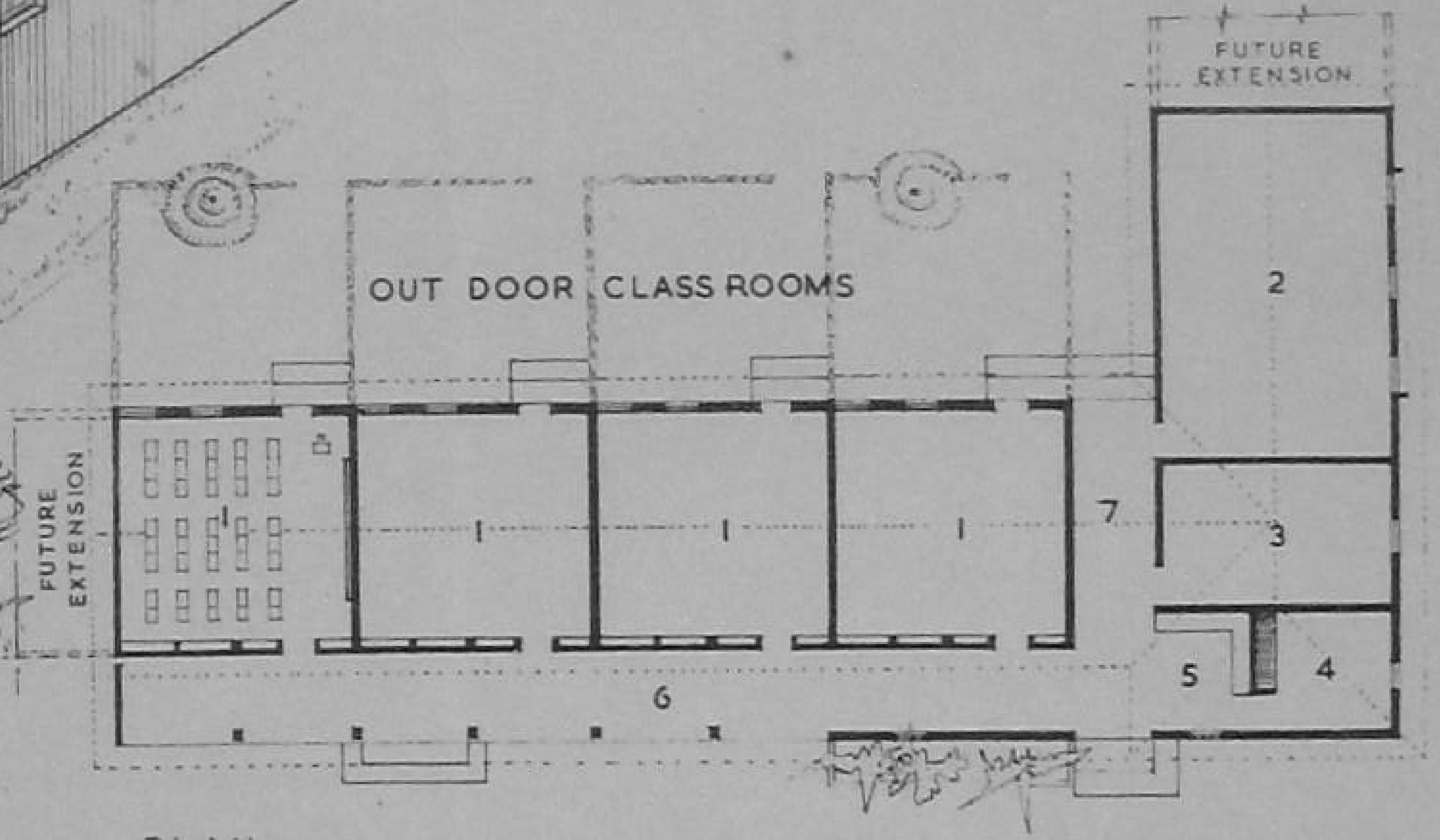
POST OFFICE (WITH S.P.M.'S QUARTER)

FIG. 4

FIG.5

1.	CLASS ROOM	6·0m x 6·0m
2.	MULTI-PURPOSE HALL	6·0m x 9·0m
3.	HEAD MASTER	6·0m x 3·65m
4.	STORE	3·65m x 3·0m
5.	WAITING	2·45m x 3·0m
6.	VERANDAH	2·15m WIDE
7.	PASSAGE	2·15m WIDE
	PLINTH AREA	356 SQ.M



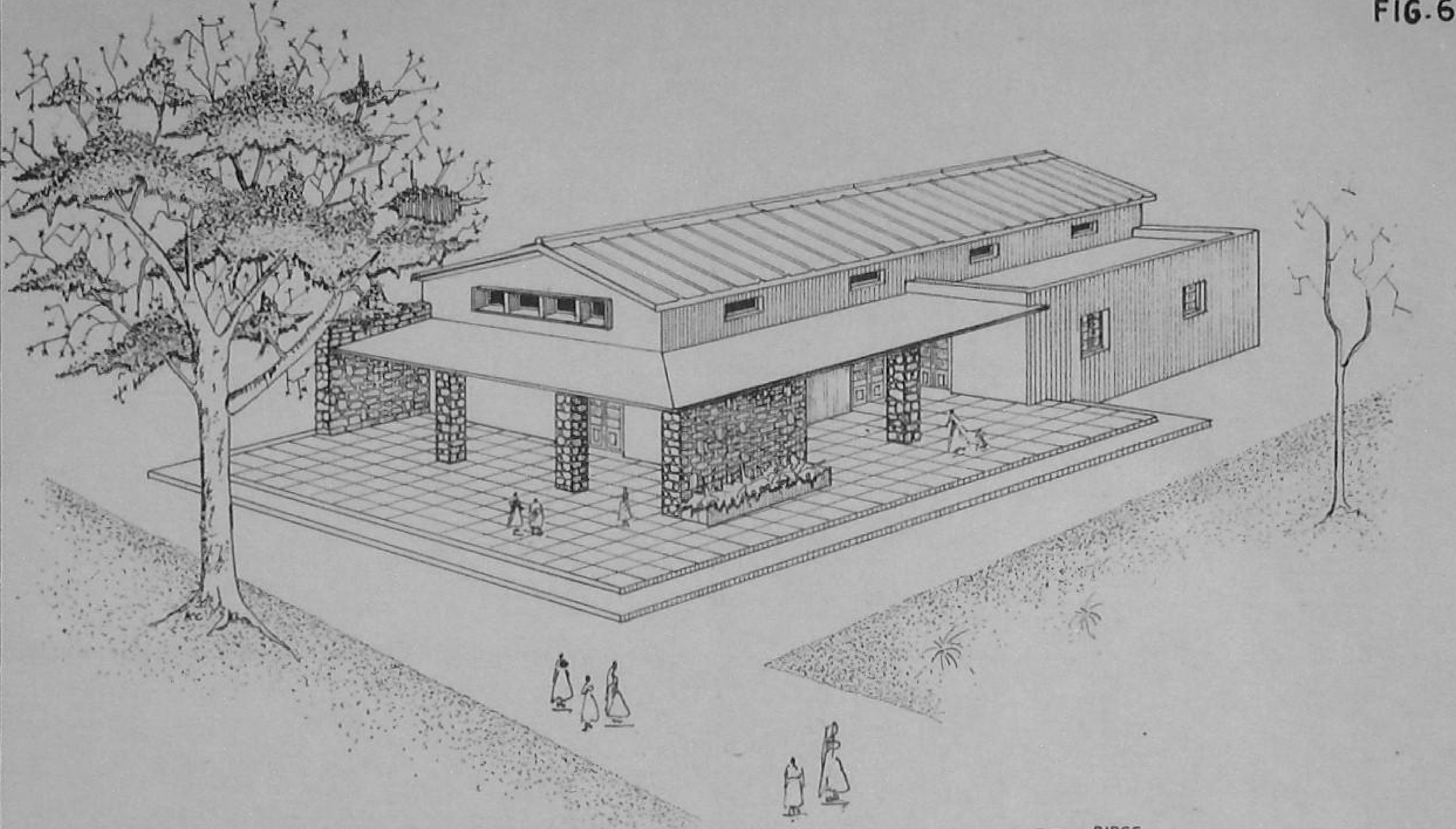


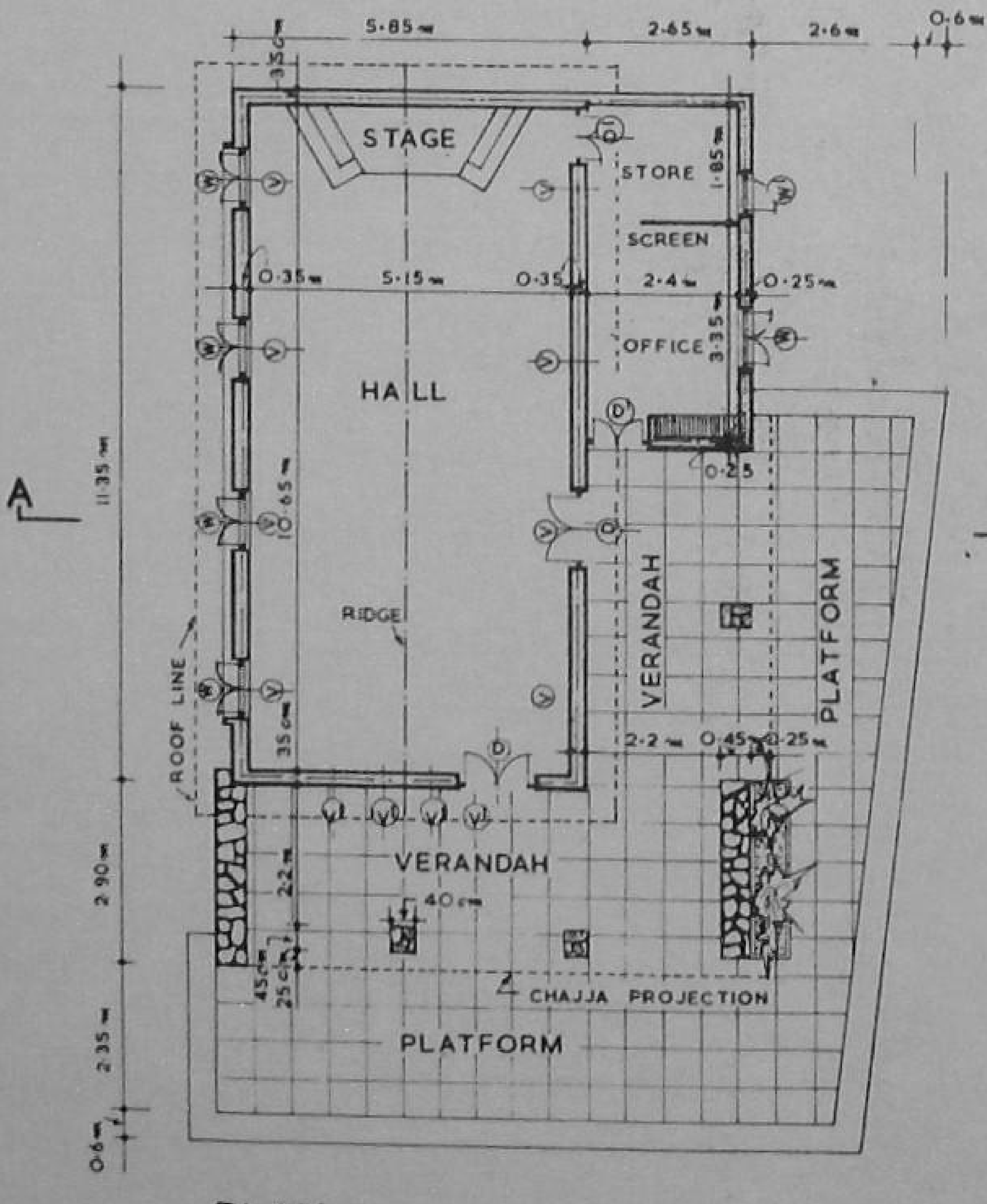
PLAN

A PRIMARY SCHOOL

KAUSHALA.

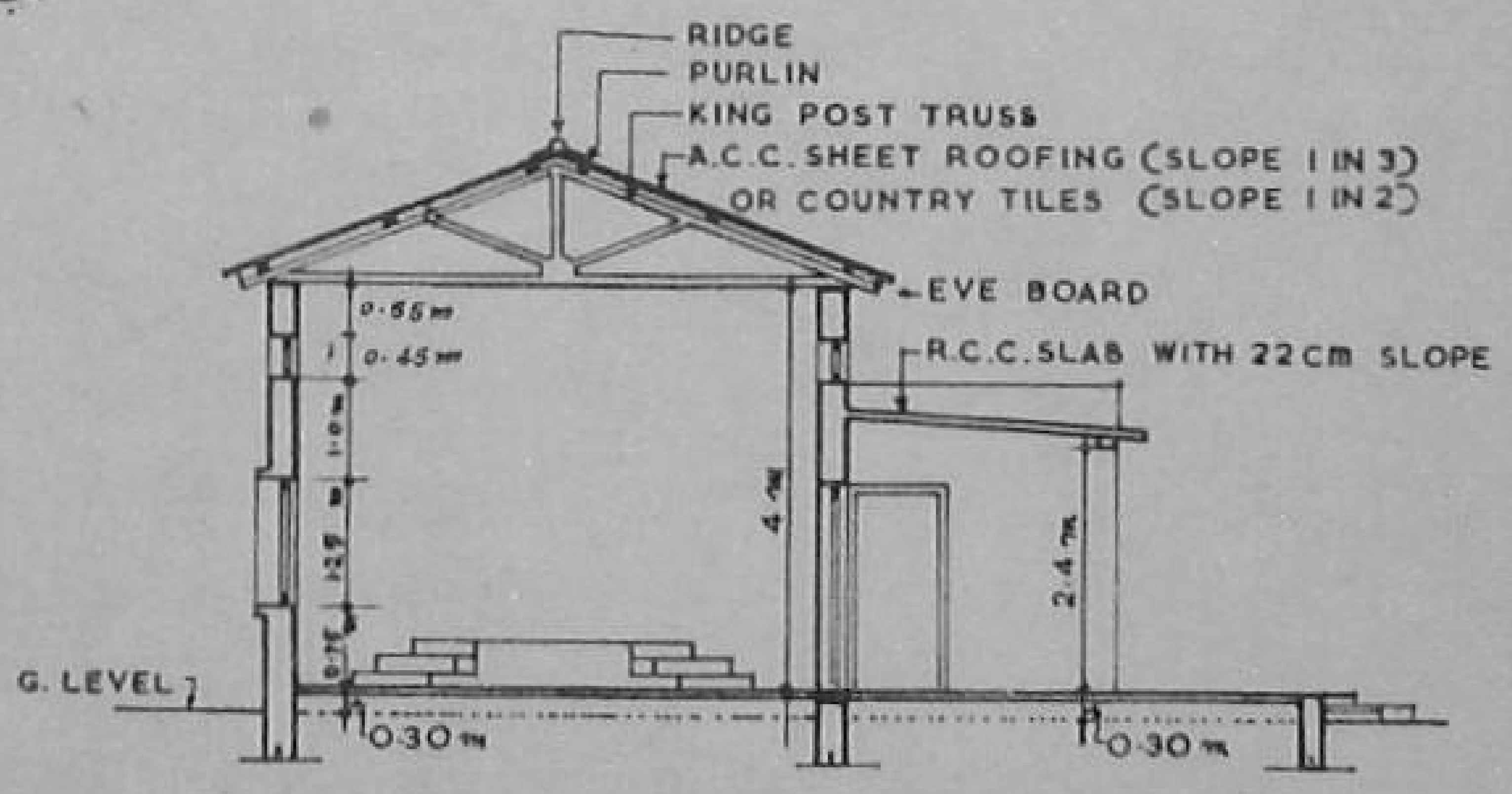
FIG. 6





PLAN

PLINTH AREA = 120 SQm



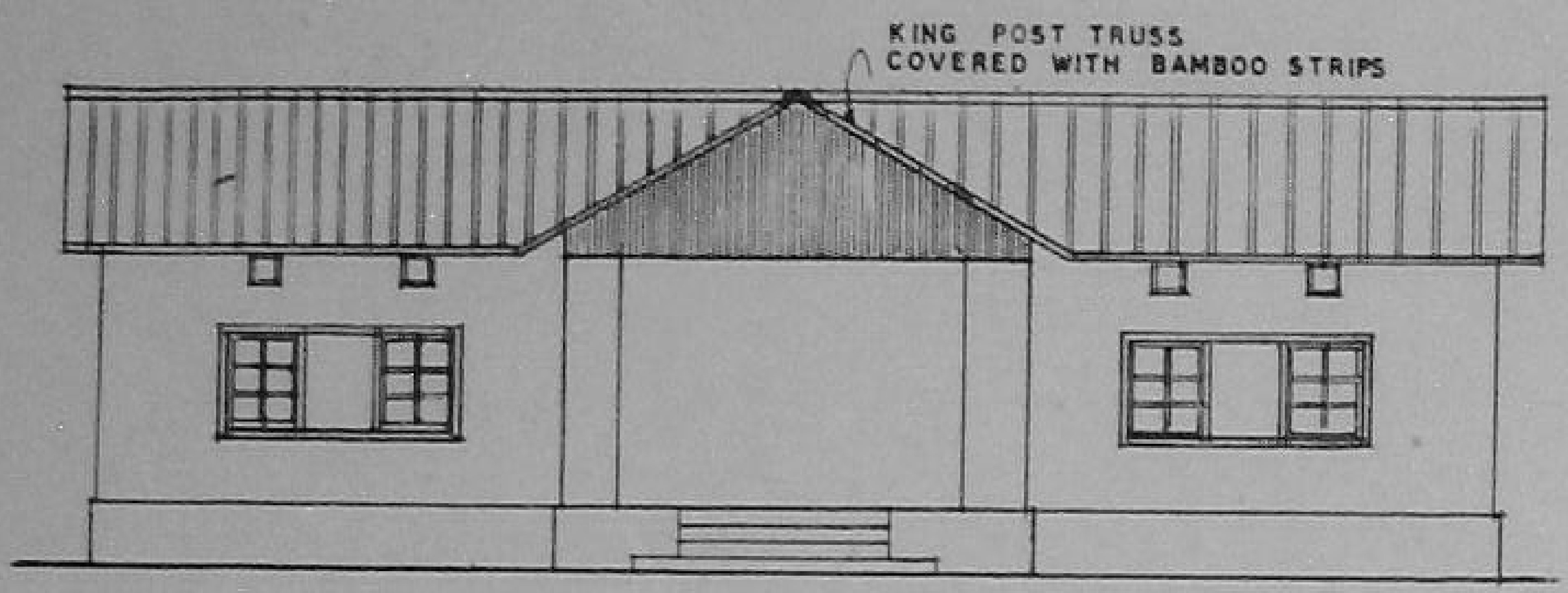
SECTION ON AA

SCHEDULE

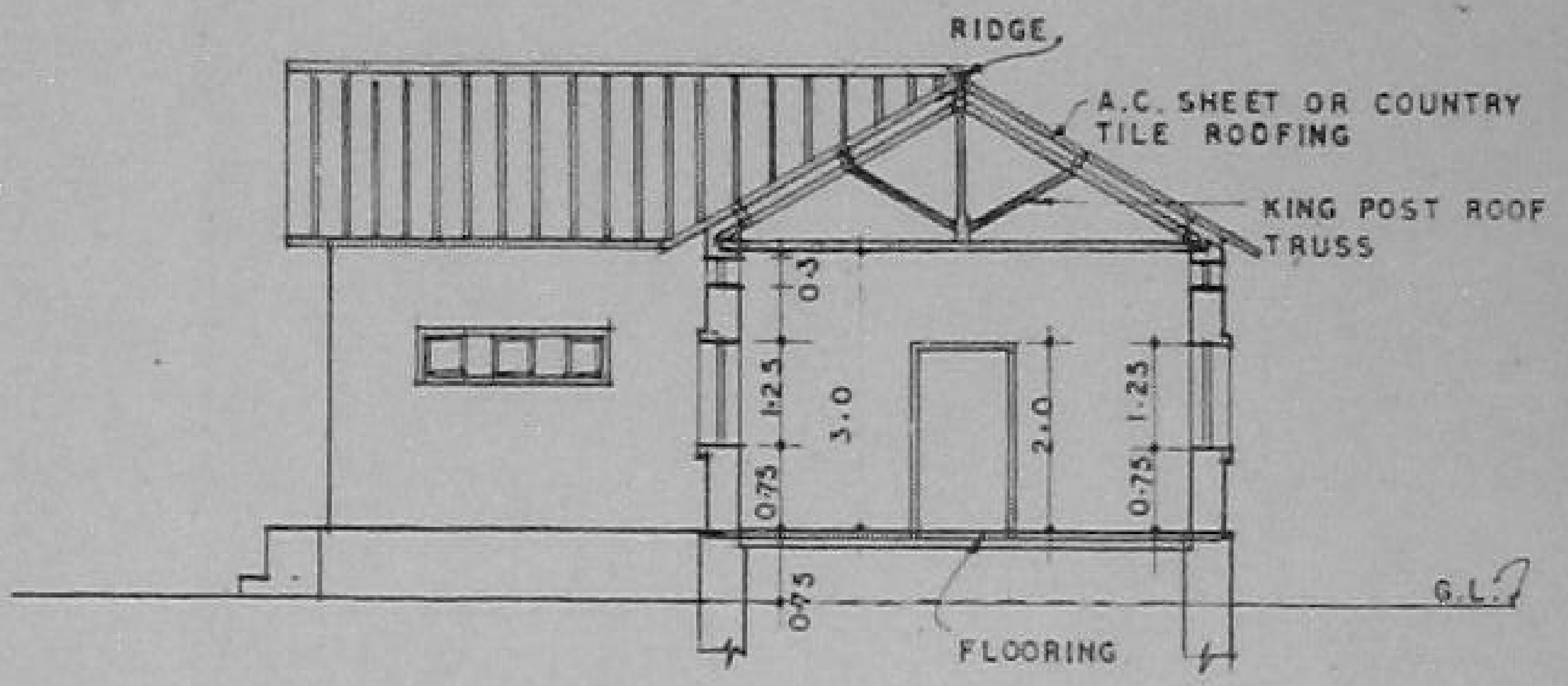
TYPE	DESCRIPTION	SIZE
D	DOOR	1·25 m X 2·0 m
D¹	DOOR	0·9 m X 2·0 m
W	WINDOW	0·9 m X 1·25 m
W¹	WINDOW	0·60 m X 0·90 m
V	VENTILATOR	0·90 m X 0·45 m
V¹	VENTILATOR	0·60 m X 0·45 m

DESIGN FOR A COMMUNITY CENTRE

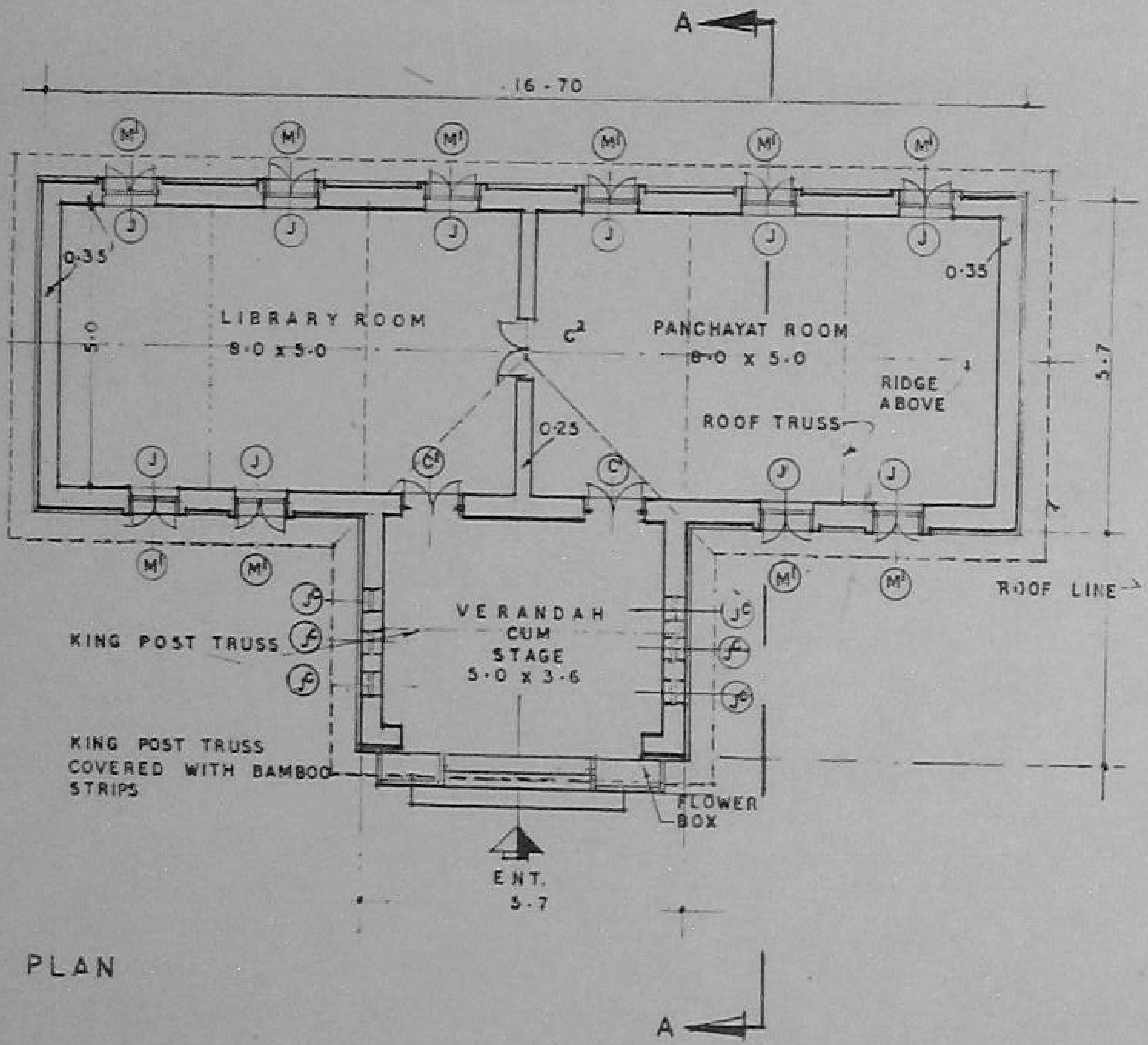
FIG.7



FRONT ELEVATION



SECTION ON A A



PLAN

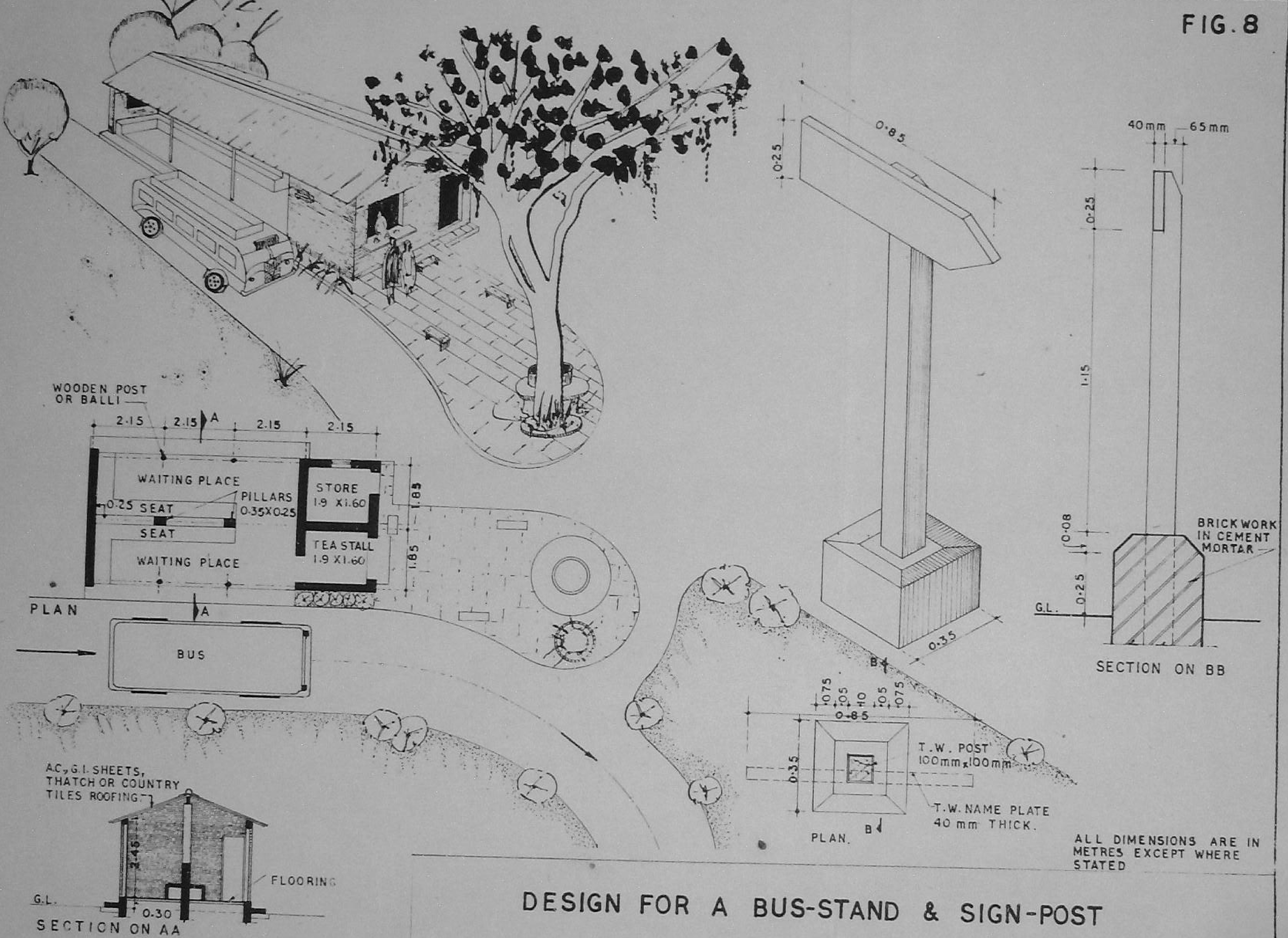
	SCHEDULE OF DOORS & WINDOWS	
C^1	DOOR PANELLED DOUBLE HUNG.	1.25m x 2.0m
C^2	" " " "	1.0m x 2.0m
M^1	WINDOW GLAZED DOUBLE HUNG.	0.9m x 1.2m
J^C	CONCRETE JALI	0.45m x 0.45m
J	" "	0.3m x 0.3m

PLINTH AREA = 115 SQ METRES

A PANCHAYATGHAR & A LIBRARY WITH A MULTI-PURPOSE STAGE

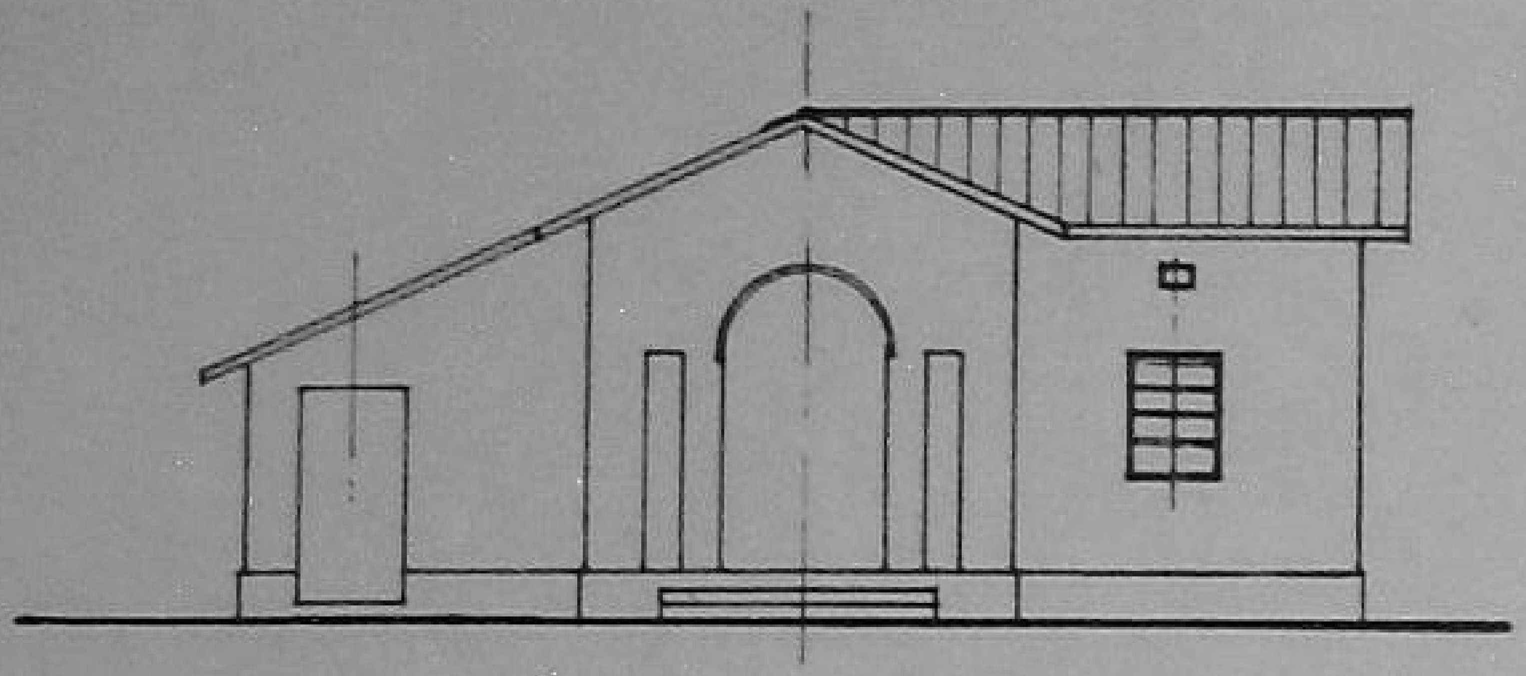
ALL DIMENSIONS ARE IN METRES

FIG. 8

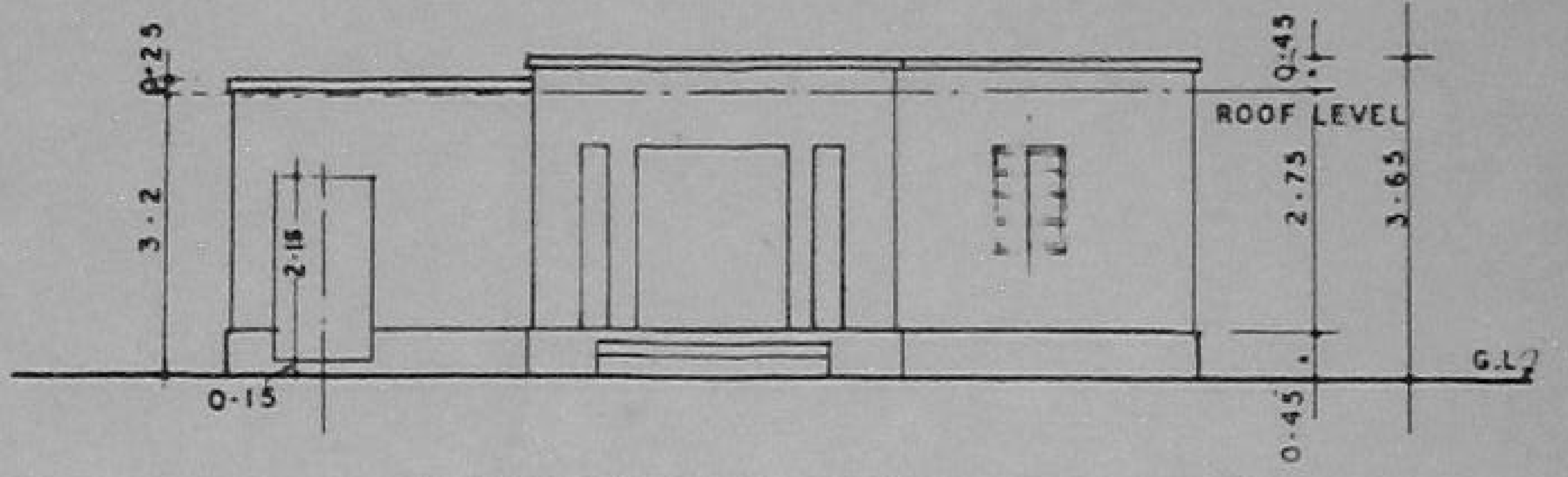


DESIGN FOR A BUS-STAND & SIGN-POST

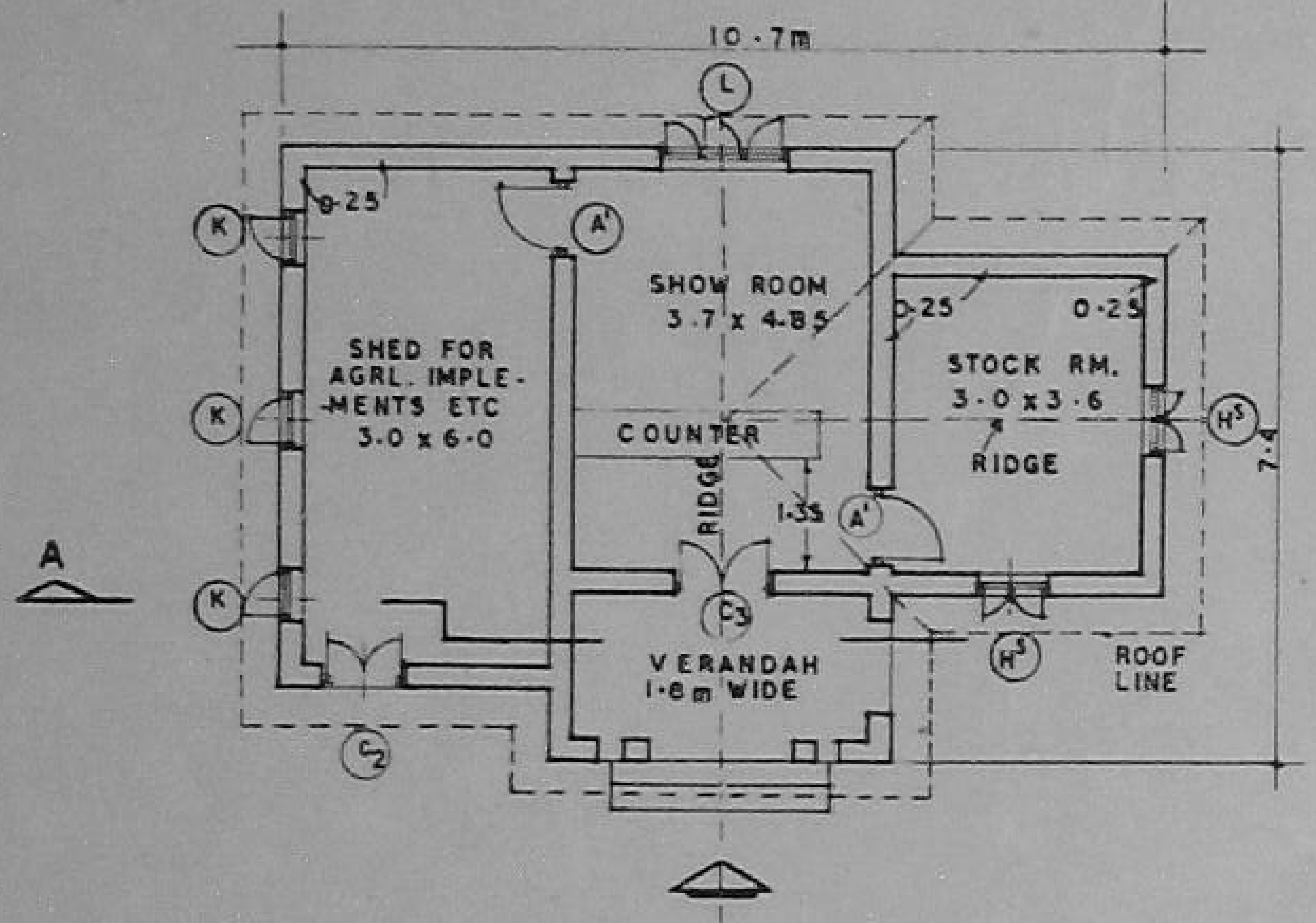
FIG.9



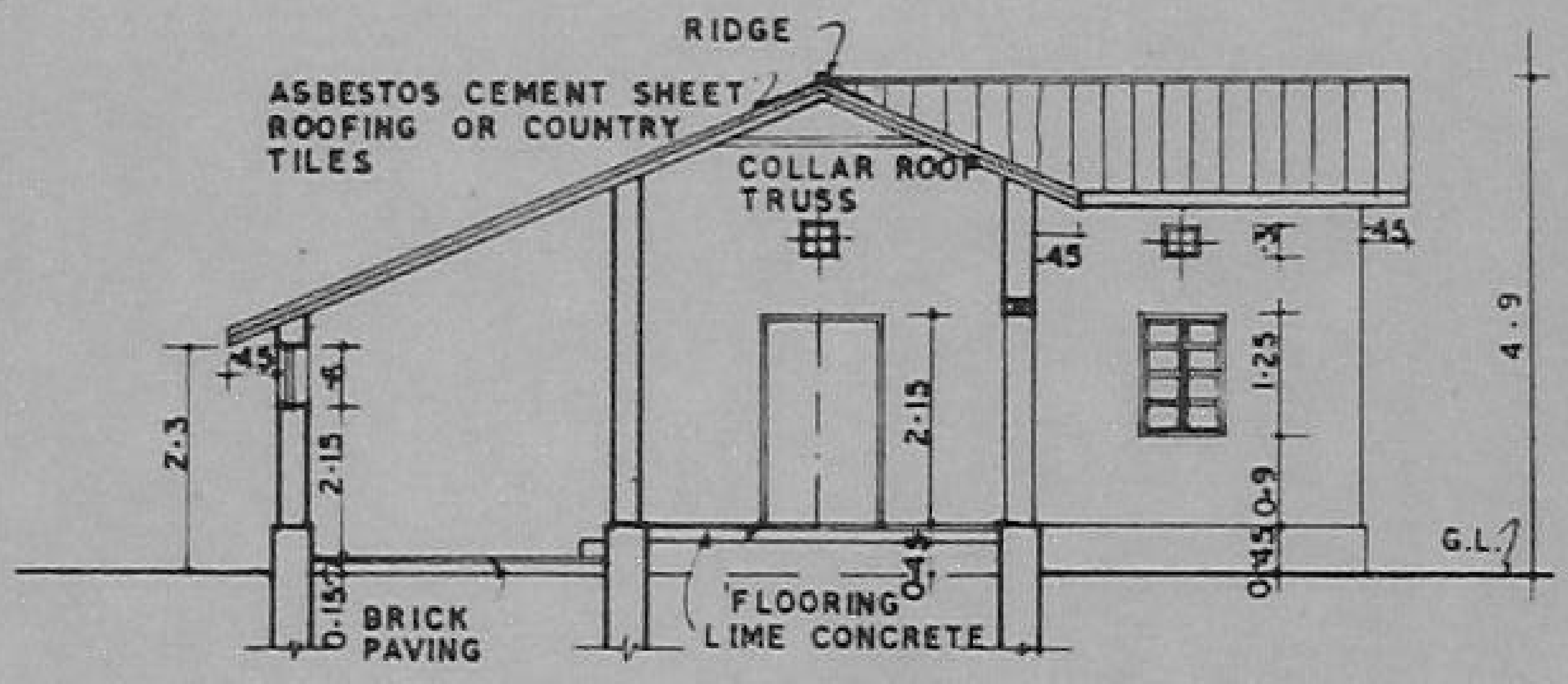
FRONT ELEVATION (PITCH ROOF)



FRONT ELEVATION (FLAT ROOF)



PLAN.



SECTION ON AA (PITCH ROOF)

CO-OPERATIVE CONSUMER STORE

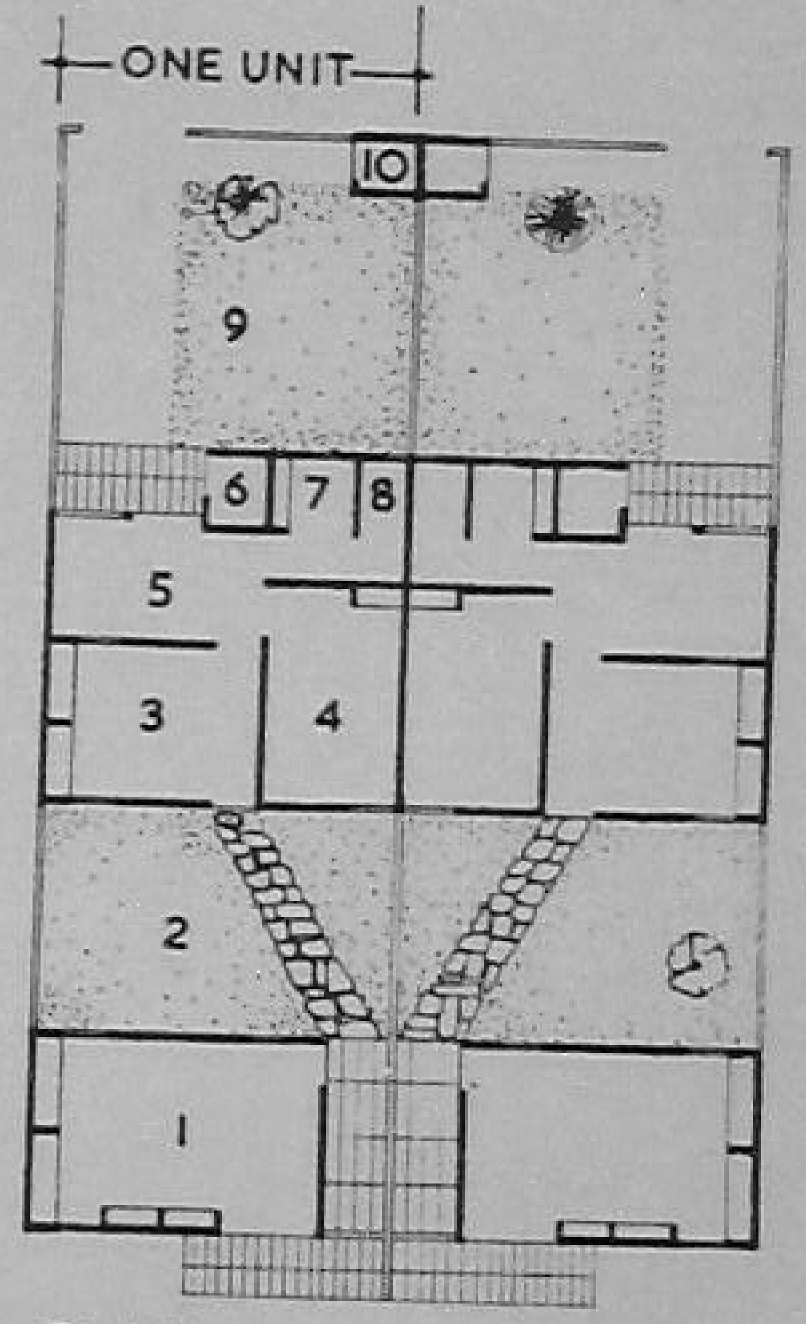
ALL DIMENSIONS ARE IN METRES

SCHEDULE OF DOORS & WINDOWS		
C_3	DOOR PANELLED DOUBLE HUNG	1·25m x 2·15m
C_2	DOOR PANELLED DOUBLE HUNG	1·00m x 2·15m
A^1	DOOR PANELLED SINGLE HUNG	0·90m x 2·15m
H^S	WINDOW GLAZED DOUBLE HUNG	0·85m x 1·25m
L	" " WITH THREE SHUTTERS	1·50m x 1·25m
K	" " SINGLE HUNG	0·60m x 0·60m

FIG. 10

1. SHOP . . . . 6 m x 3.6 m
2. INNER COURT YARD . 7.5 m x 4.6 m
3. ROOM . . . . 4.25 m x 3.0 m
4. ROOM . . . . 2.9 m x 4.25 m
5. VERANDAH . . . . 2.4 m WIDE
6. BATH . . . . 1.2 m x 1.5 m
7 & 8 KITCHEN & STORE . . 2.8 m x 2.45 m
9. BACK COURT YARD . . 7.5 m x 6.5 m
10. LATRINE . . . . . . 1.2 m x 0.9 m

- PLINTH AREA . . . 78.6 SQ. m



PLAN

SHOP CUM RESIDENCE

8 Building Materials

8.1. Soil as a Material of Construction

8.1.1 Since the dawn of civilization, soil has been utilized for building either in the form of burnt or sun-dried bricks, cob construction, *pise de terre* (rammed earth) or combined with jungle wood and reeds. Soil consists largely of mineral matter formed by disintegration of rocks. The soil particles are characterised by their grain sizes. The Indian standard classification of soil is as follows:

	Greater than mm	But less than or equal to mm
Gravel	2	60
Sand, coarse . .	0·6	
Sand, medium	0·2	0·6
Sand, fine	0·06	0·2
Silt, coarse	0·02	0·06
Silt, medium	0·006	0·02
Silt, fine	0· 02	0·006
Clay	..	0·002

8.1.2 The conventional method of constructing mud walls is to convert the soil available at site into mud with the addition of water. Lumps of such mud are piled one over another and the wall is then raised up. The mud wall is plastered with the paste of the same soil mixed with small quantities of cow-dung and straw. This method of raising the wall is not scientific and results in early deterioration of the structure. Moreover the walls are not straight. This type of construction should, therefore, be discouraged.

8.1.3 Soil is used as a construction material in two other types of construction, namely, *pise de terre* or rammed earth and adobe or sun dried bricks or blocks.

In pise construction the soil is rammed into forms to construct a solid mass wall (monolithic construction) with the help of shuttering. The soil inside shuttering is tamped with a rammer at the optimum moisture content. The optimum moisture content is the moisture content at which under given conditions of compaction, maximum dry density is obtained. The correct test to see if the soil is at its optimum moisture content is the "ball test". A handful of soil is taken and squeezed between the fingers. If the soil 'balls up' together, there is enough moisture, but should it crumble after the pressure being removed, then more moisture should be added. Pise blocks of convenient size can also be manufactured. The villagers can make these blocks during slack periods and these can be used for constructing the house later. It has been estimated that the cost of producing pise blocks by a block making machine is almost the same as that of making sun dried bricks. But the machine made blocks have the advantage of higher density, higher strength and uniformity of shape.

The term 'adobe' originated from the Spanish word meaning a building material consisting of loam, straw and other material. In adobe type of construction, the usual practice is to mould the earth into blocks and build the blocks thus obtained into walls after they have been dried.

The block method of construction provides for the shrinkage of the small unit before being laid into a wall. The danger of serious shrinkage and cracking, which might occur when using soil of high clay content in the large unit of monolithic construction (as in *Pise-de-terre*) is thereby reduced to a minimum. A greater technical skill is needed for pise type of construction, while adobe is more convenient and is, therefore, preferable for the construction of village houses.

8.1.4 *Suitability of Soil*—Earth is considered by pise builders suitable if it contains not more than 50 per cent of clay including loam and silt and not less than 50 per-cent of sand. The best consistency, however, according to conclusions reached at the Commonwealth Research Laboratory, Australia is as follows:

Clay including silt by loose volume—30 per cent.

Sand and other granular material—70 per cent. If the earth at the building site is not of the required composition, it may be mixed with other suitable earth to bring it to the composition desired.

Earth containing less than 50 per cent of sand is more suitable for adobe type of construction.

8.1.5 *Sun-dried Bricks*—Sun-dried bricks are moulded from clay and dried in the sun. These are, however, incapable of withstanding softening and erosive action of rain water. Tests carried out at Building and Road Research Laboratory, Chandigarh have indicated that if coal tar is added at the rate of 0·5 to 1 percent by weight of soil, the bricks become very resistant to softening and erosive action of water. This also improves the compressive strength of bricks both in dry and wet state.

8.1.6 *Stabilized Soil*—Most of the natural soils except the non-plastic ones can be compacted under proper moisture conditions to dense mass having a high compressive strength in dry state but when the mass is wetted with water it becomes soft and loses strength. Even the best mechanically stabilised soils have been generally found to have very low resistance to the softening action of water. Hence they need some chemical treatment to make them water resistant so that the structures made with them can withstand the erosive action of heavy showers of rain or the water logging conditions of the subgrade.

This brings us to the conception of "stabilization". A suitable soil, compacted at optimum moisture content can be made into a strong and durable material by the addition of a stabilizing agent, which must enable the material to retain its shape and a significant proportion of its strength even when wetted to the point of saturation. Various types of stabilizing agents have been used. Some are substances which act as waterproofing media and of these, bitumens, asphalts and certain resins are the most important. Others are substances which acquire and retain rigidity with the addition of water and so give a rigid skeleton to the compacted soil. Of this type, Portland cement is most commonly used and there is now a large fund of experience of Portland cement as a stabilizing medium. Finally there are substances which react chemically or physically with certain of the soil constituents to give stable, rigid products in the presence of water. In this category lime is the most important, but by no means

all soils will be found to be reactive with lime; so that it is necessary to make preliminary tests to find whether lime will give the required stability.

The quantity of cement added to soil for stabilization varies from 2·5 to 5 per cent normally. Sandy soils require less amount of cement for stabilisation while clayey soils need more cement. Incorporation of small quantities of lime in the 'Soil-cement' mixture has been found to improve the wet compressive strength and resistance to weathering and also reduce the cement requirement. Lime alone is equally satisfactory in case of clayey soils but in sandy types it is less effective.

It has been found that the use of 1 % cement and 1 % lime in a stabilized soil mass gives better results than 2·5 per cent cement alone and the use of 2 per cent cement and 2 per cent lime is almost as good as 4 to 5 per cent cement alone. This will show that cement which is a more costly material can be partly replaced by a cheaper material like lime (which has slow setting properties) without having any adverse effect on the properties of the resultant stabilised soil mass. Also addition of lime has the advantage that a soil mixture containing this can be handled more leisurely than if large quantity of cement, which sets quickly is present. Both these materials also slightly reduce the water absorbing capacity of the mass and the wet saturated soil mass containing these chemicals remains fairly hard and stable. More clayey soils generally need higher quantities of cement but these can be reduced by first changing the physical properties of the soil by thoroughly mixing it with 2 to 3 per cent lime. A freshly slaked lime is preferred.

Out of the various industrial bye-products tried so far, the use of molasses has been found to be most effective both for improving the compressive strength and reducing the permeability and capillarity of the soils. This material is equally effective with silty and sandy soils. In the case of clayey soils, however, small quantities of lime in conjunction with molasses give quite satisfactory results. The addition of molasses also considerably increases the impermeability and resistance of stabilised soil mass to the abrasion and thus it can be used for stabilised soil flooring and on the roofs for checking the leakage. Its addition in soils rich in soluble sulphates, helps in checking efflorescence. For stabilization purposes, the quantity of molasses normally added to the mass is 5 per cent by weight of soil.

The soil mass should be thoroughly pulverized and blended before adding the stabilizing agents. The optimum moisture content normally varies from 12 to 18 per cent. When lime is used as a stabilizing agent, it should be mixed with dry soil and then the required amount of water should be added. Cement should be added after the addition of water.

Two general building methods can be distinguished in stabilized soil construction. One is *in-situ* construction in which walls are erected by ramming soil with the help of shuttering. Thus, large sections of walls can be obtained in one operation. This is one of the oldest methods of soil construction and represents the traditional approach.

In the other system, soil blocks are previously moulded and then used in the erection of walls as any other brick. The advantage of any of these systems will be determined by local conditions and the type of construction required. However, *in situ* techniques are not advisable for soils with high clay content because walls will be subjected to shrinkage and cracking, thus weakening the structure of the house. Under these conditions, block construction is more advisable as hand-moulded blocks can be properly cured before being utilized in erecting the walls. There are also other advantages in hand made block construction, such as reduction of wall thickness and greater accuracy in erecting the walls.

Several techniques can be adopted in the case of block making. The simplest consists of ramming soil by hand inside a detachable wooden mould, the approximate size of a brick. More advanced methods are available in the form of hand-operated block pressing machines that allow application of much more compression than exerted by hand as well as a higher daily output (some of these machines can put out up to 2000 units per day). The usual sizes of blocks are 30 cm × 22·5 cm. × 10 cm. .30 cm X 15cm X 10 cm, and 30 cm X 20 cm X 10 cm. The 'Ellson, Blockmaster' block making machine manufactured by Kathiawar Metal Tin Works (P) Ltd; Rajkot costs Rs. 1,500.

Precautions must be taken in handling and curing of fresh blocks. When ejected from the press they should be carefully deposited in single rows on clean even ground. They should not be loaded with new rows for at least 24 hours. While stocking blocks for curing no more than 5 rows should be allowed. Blocks must be cured in shade so that moisture is eliminated slowly. This can be done in a shed, or in its absence, blocks can be covered with branches or large leaves. For the first four days, they must be sprinkled lightly with water twice a day. After 28 days, the blocks may be laid up in walls. However, the older the blocks the better they are, for building purposes.

8.2 Bricks

8.2.1 Burnt clay brick is the principal potential building material for rural houses. The villagers always prefer a 'pucca' house which should last for a long time and give them social prestige and status. In most parts of the country bricks can be easily manufactured in rural areas. Brick is the real answer to materials required for rural housing. Stabilized soil construction will be useful only in those areas where soil is not suitable for brick making or coal and other fuel is available with difficulty.

8.2.2 With the limited resources at their disposal the brick makers in rural areas usually utilize whatever soil is locally available and make only minimum modifications in its composition which are absolutely essential for moulding. However, investigations made at the Central Building Research Institute, Roorkee have indicated certain broad limits within which the mechanical grading of the soil should be in order to obtain the requisite strength, low water absorption and other essential requirements. Wherever feasible the soil should be got tested in a laboratory.

8.2.3 *Site Selection*—It is a good practice to select a site such that the water table during burning season is at least about one metre below the kiln floor level.

8.2.4 *Soil Selection*—The soil used for making building brick should be free from gravel, coarse sand, lime and kankar particles and vegetable matter. The mechanical grading of the soil should be as follows:

Clay—20 to 30 per cent by weight.

Silt—20 to 35 per cent by weight.

Sand—35 to 50 per cent by weight.

The total content of clay and silt should not be less than 50 per cent by weight.

Liquid limit—25 to 38 per cent.

Plasticity index—7 to 16 per cent.

Volumetric shrinkage—15 to 25 per cent.

Note :—This grading is not applicable to black cotton and lateritic soil.

8.2.5 *Preparation of Soil*—Water amounting to ¼ to 1/3 by weight of soil is added to the soil. Sandy soils require less water while clayey soils need more water. The mixing of the soil is done by kneading and with the help of spades. After this, the bricks are moulded and dried in sun for about eight days.

8.2.6 *Burning of Bricks*

(a) *Temporary brick kilns*—The temporary kiln is made out of the bricks which are to be burnt in the kiln. Such a kiln can be very quickly made. With a temporary kiln about 1800 bricks can be burnt at one time. (*See Fig.* 1). The method of constructing temporary kiln is as follows:

1. First of all a lot of 1800 dry bricks is separated out.
2. The bricks are arranged as shown in the sketch. In one row the bricks are set lengthwise and in the other they are kept on their edges (1). This order should be repeated in alternate rows.
3. The bricks should be arranged in such a manner that space for burning fire is left in the middle of the kiln (2).
4. The top most bricks in the kiln should be kept on their edges very close to each other so that the roof of the kiln is formed (3). In the roof so formed small spaces (4) are left for the burning of fire.
5. The outside of the kiln formed with the bricks to be burnt should then be covered with a layer of soil 200 mm thick in order to cover the bricks (5). It should be remembered that the kiln should not be covered with a layer of soil on its roof at this stage.
6. When the kiln is fired, then with the heat produced, the dampness of the bricks would be driven out and the bricks would start shrinking. Therefore, the roof of the kiln should not be covered with a layer of soil. When the bricks forming the roof of the kiln have shrunk then it is known that the dampness of the bricks has been driven out.
7. Now the roof of the kiln is covered with a layer of soil of 25 mm thickness (6). By this, the heat of the kiln is conserved and the required temperature inside the kiln for burning the bricks is developed.
8. It should be remembered that for the burning of fire, spaces (4) must be left in the roof of the kiln.

Method of burning the kiln—After the construction of the kiln, the space which is left in the middle of the kiln should be filled from both sides with dry wooden logs so that it is half full with fuel. After this the fire should be ignited. The fire should be slow and dull so long as the dampness of the bricks is not driven out. After covering the roof of the kiln with a layer of 25 mm of soil, more fuel should be added and the fire should be burnt very briskly.

The fire should be kept burning in this manner for about 10 days. After 10 days, the soil covering from the side should be scratched out at some place in order to see if the bricks have become strong and have been burnt properly. If the bricks have not become strong then firing is continued.

After proper burning of the bricks the kiln is allowed to cool. On examining the burnt bricks it will be found that about 15-20 per cent bricks have either broken or are not fit for use.

(b) *Permanent brick kilns*—The method of constructing permanent kilns would be clear from Fig. 2. The advantage of a permanent kiln is that several loads of bricks could be burnt in the same kiln. This is not possible in the case of ordinary temporary kilns. Another advantage is that the bricks could be set into the kiln very quickly as two of its walls are permanent. Permanent kilns are made only at such places which have been selected on somewhat permanent basis for brick manufacturing. Depending on the size of the kiln a definite number of bricks could be burnt at a time.

The two walls of the kiln which are permanent ones are made of burnt bricks and mud mortar. The rest of the walls of the kilns are constructed with the bricks which are to be burnt as in the case of temporary kilns. In the kiln, the sketch of which is given here, about 16,000 bricks could be, burnt at a time; but when necessary by decreasing the dimensions of the kiln lesser number of bricks could also be burnt. In any case burning of less than 10,000 bricks in permanent kilns does not prove to be economical.

A site which is even and dry should be selected for the construction of the permanent brick kilns. The trench for the kiln should be dug at such a place where the front and the back walls of the kiln could be constructed. This trench should be 3600 mm long and 300 mm deep. It is better if the trenches are dug deep so that hard soil is met with and the foundations of the permanent walls of the kiln could be strong. The front and the back walls of the kiln are made of the same shape and dimension. The thickness of the permanent walls should be 330 mm up to 1800 mm height. The lower portions of the walls should be in the trench and if some space is left around, it should be filled with the soil and rammed properly. The lower portion of the wall which is below the ground level should be made of burnt bricks and the part of the wall above the ground level could be made of unburnt bricks and mud mortar. When the walls have been constructed up to the height of 1800 mm then the thickness of the rest should be reduced by 100 mm, *i.e.* the thickness of the rest should be reduced from 330 mm to 230 mm. In this manner the top portions of the walls are constructed thinner than their lower portions. By making the lower portions thicker, the walls are able to withstand the pressure of the bricks and by keeping the upper portions thinner the load on the wall is reduced. The upper portion of the wall which is 230 mm thick is further raised to a height of 1780 mm.

The method of construction of this wall is very important. The first layer of the bricks in the wall is laid on their edges as shown in sketch (A). After this a layer of mud mortar is applied on it and the second layer of bricks is laid (5). Again mud mortar is applied over it and the third layer of bricks is laid as shown in sketch (c). In this way as shown in (6) a layer of mud mortar and another of brick are laid. When the thickness of the wall equals the length of the brick then half bricks are used. The method of laying the bricks is shown in the figure.

For supply of fuel in these two walls (as shown in the sketch) at least three spaces should be left. These spaces should be made in the form of tunnels running through the kiln.

Method of loading the brick kilns—When the front and the back walls of the kilns have been constructed, brick paving is done between these walls to form the floor of the kilns. For making the floor the bricks should be set very closely to each other and mud mortar should be used. Unburnt bricks could be used for making the floor of the kiln. As shown at (9) in the figure unburnt bricks are arranged in square heaps in the kiln. The square heaps of the bricks are of three bricks length. These are raised from the floor up to the top of the kiln.

For the first loading of the kiln three bricks are laid (10) on their edges with their faces parallel to the walls.

Behind these at a distance of 16 mm another row of bricks is laid in a similar manner. After this three bricks are laid so that their edges are parallel to the walls at a distance of 16 mm to each other. Like this the two rows of bricks are laid at right angles. In this order the bricks are laid to form the heap up to the top of the kiln. In every heap a space of 16 mm should be left so that the bricks could be heated from all sides.

While forming the heaps of bricks in the kiln three spaces (8) should be left for the fuel—a space of 460 mm width and 1470 mm height should be left. When the bricks have been arranged in the kiln up to the height of 1470 mm then the roof of the kiln (12) is formed by filling in a solid layer of bricks in between the walls. By forming the roof of the kiln, first the temperature of the kiln is reduced a little and bricks are also burnt well. On shrinking of the bricks some cracks are formed in them and the heat coming out through these helps in burning the bricks. The roof of the kiln is covered with wet soil so that the heat of the kiln may not be wasted and bricks are burnt well. Now a layer of 15 to 20 mm thickness of wet soil is pasted on all sides of the kiln (13). Like this the kiln is prepard which is ready for firing.

Burning the kiln—First of all through the front and the back walls fuel is filled in the kiln. In the beginning the fires are kept dull so that the dampness of the unburnt bricks could be extricated in the form of steam. In the day time the dampness of the bricks in the form of steam is not visible, but at night it is clearly visible. For two days and two nights the dampness of the bricks should be allowed to go off in the form of steam. The steam as it comes off dampens the bricks which form the roof of the kiln. When the bricks forming the roof of the kiln have dried then the roof should be covered with a paste of wet soil completely, but in the roof four spaces must be kept open for the flue (15).

Before pasting the soil on the roof, bricks standing on edges should be laid flat (14) so that they do not crack. For covering the roof of the kiln, a paste of soil of thickness of 15 mm is enough (16). After covering the roof the intensity of fire should be increased.

With the increase of temperature in the kiln, the bricks shrink and the roof starts sinking a little. It should be kept in mind that the roof should not be allowed to sink here and there. Where there is more of heat, the roof sinks. For decreasing the temperature inside the kiln around that spot, the hole left for flue in the roof near to it should be closed by putting a brick over it and covering it with a paste of soil. By doing so the temperature round that spot is reduced and the roof stops sinking further there. Due to loss of heat at some places the roof does not sink. In such circumstances one brick is removed from the roof of the kiln to provide the hole for the flue. By doing so that part of the roof gets more of the heat and so it sinks. In this manner every effort should be made to keep the entire roof at the same level.

Ordinarily bricks are burnt in a period of seven days. As far as possible the temperature of the kiln should be kept constant. For this the quantity of fuel required is increased or decreased as the case may be and effort is made to keep the roof of the kiln at the same level as mentioned above.

When the bricks are burnt, the kiln is left to cool down and this takes about three to four days.

When the kiln is cooled bricks are removed from it. The burnt bricks which have broken or badly deformed or have clogged to each other should be sorted out. The rest of the bricks could be used for construction.

When the burnt bricks have been completely removed from the kiln, the permanent wall of the kiln and the floor are left as such. For reusing the kiln a fresh load of unburnt bricks is put into the kiln and the process of burning is repeated.

(c) *Bull's kiln*—For carrying out brick manufacture on a permanent basis bull's kiln is used. This kiln is designed on scientific principles; as such the burning is done properly and the fuel consumption is also less as heat losses are minimised. See Fig. 3 for details.

8.2.7 *Method of Making Good Brick from Black Cotton Soil*

Black cotton soils are used for the manufacture of bricks in Central and Western India. They, however, present some inherent difficulties, because of their highly plastic nature, excessive drying and firing shrinkages and the presence of nodular lime. In order to avoid these, coal ash is normally added to the soil but the resulting bricks are generally of low strength, have high water absorption and exhibit lime bursting. In certain areas, grass and straw are added instead of coal ash, but the bricks produced are still very poor.

Investigations carried out at Central Building Research Institute, Roorkee have shown that the addition of 20 to 30 per cent of powdered grog (clay calcined at 500-600 °C) to the soil produces superior bricks. Their compressive strength and water absorption is 70 to 140 kg/sq. cm. and 15 to 20 per cent respectively, as compared to 20 to 40 kg/sq cm and 25 per cent respectively for bricks made by conventional methods.

For calcination, large lumps of clay about 10 cm size are hand picked and set in the form of a clamp. A layer of coal ash about 10 cm thick is spread at the bottom over which 25 to 30 cm layer of clay lumps is arranged. Sufficient air space is left in the setting for the circulation of hot gases. The clamp is heated by burning cow dung cake and other refuse in the flue constructed at its bottom. When the fuel in the topmost layer is burnt out, a part of the side wall is pulled down to allow quick cooling of the clamp. Larger grog lumps are broken to smaller sizes by a wooden hammer and these are fed into a disintegrator which reduces the lumps to a fineness of 1·6 mm.

After the separation of raw clay from kankar by the usual Ghol method, the clay is mixed with grog, roughly in 2:1 proportion. The mix is allowed to dry till it attains a suitable consistency for moulding. It is then pugged and kneaded manually and the bricks are moulded in a wooden mould lined with G.I. sheets.

Black soils generally contain large proportion of nodular lime. During firing, the nodules decompose into calcium oxide, which on subsequent exposure to atmosphere, reabsorbs carbon dioxide forming calcium hydroxide and carbonates. This reaction contributes to localised expansion which results in flaking and disintegration of bricks, called lime bursting. Several methods can be used to prevent lime bursting. Addition of 0·5 to 1 per cent sodium chloride or 5 to 10 per cent coal ash is one of them. Immersion of bricks in water soon after removing it from the kiln, known as docking, prevents, bursting provided the size of lime particles is less than 2 mm.

8.3 Building Stones

8.3.1 Stones have been used for building purposes from times immemorial. Building stones are obtained from rocks occurring in nature. Rocks are divided into three main types:

(a) Igneous,

(b) Sedimentary, and

(c) Metamorphic.

8.3.2 *Igneous Rocks*—Those rocks which cool from a molten condition. They have crystallized from a hot fluid mass called magma. Principal stones obtained from these are:—

(i) Granite,

(ii) Basalt and trap.

8.3.3 *Sedimentary Rocks*—Rocks laid down as sediments through the agency of water, wind or glaciers. Sedimentary rocks consist of grains of minerals which are cemented together by a binding material which is calcareous ($CaCo_3$), ferrugenous (iron oxide), silicious ($Si\ O_2$) or argillaceous (clay). They usually show the bedded structure arranged in layers. Principal stones obtained from these rocks are:

(i) Sand stone,

(ii) Shales,

(iii) Lime Stone, and

(iv) Laterite.

8.3.4 *Metamorphic Rocks*—These are rocks originally formed in either of the above two processes but subsequently changed or metamorphosed in colour, structure and texture due to intense heat and pressure below earth's crust. Principal stones obtained from these rocks are:—

(i) Quartzite,

(ii) Schist,

(iii) Slate,

(iv) Marble, and

(v) Gneisses.

8.3.5 *Properties of Principal Building Stones*—Properties of Principal Building Stones, found in different parts of the country are given in the following table.

PROPERTIES OF PRINCIPAL BUILDING STONES

Sl. No.	Name of Stone	Locality where found	Density kg/cu m	Compressive strength kg/sq cm
1	*Granite*	Andhra Pradesh, Assam, Bihar, Gujarat, Himachal Pradesh, Jammu & Kashmir, Kerala, Madras, Maharashtra, Mysore, Orissa, Punjab, Rajasthan, and West Bengal.	2640 to 2800 kg/cu m	770 to 1300 kg/sq cm
2	*Basalt & Trap*	Madhya Pradesh, Maharashtra & West Bengal	2850 to 2960 kg/cu m	1530 to 1890 kg/sq cm
3	*Sand Stone*	Andaman Islands, Andhra Pradesh, Bihar, Gujarat, Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Madras, Punjab, Rajasthan, Uttar Pradesh & West Bengal.	2240 to 2400 kg/cu m	650 kg/ sq cm
4	*Lime Stone*	Andaman Islands, Andhra Pradesh, Bihar, Gujarat, Himachal Pradesh, Madhya Pradesh, Punjab, Rajasthan, Uttar Pradesh and West Bengal.	2400 to 2640 kg/cu m	550 kg/sq cm
5	*Laterite*	Andhra Pradesh, Bihar, Kerala, Madras, Maharashtra and Mysore.	2080 to 2400 kg/cu m	18 to 32 kg/sq cm
6	*Quartzite*	Andhra Pradesh, Delhi, Gujarat, Himachal Pradesh, Madras, Mysore, Punjab, Rajasthan, Uttar Pradesh and West Bengal.	2600 kg/cu m	
7	*Schist*	Gujarat, Madhya Pradesh, Rajasthan and Uttar Pradesh.		
8	*Slates*	Bihar, Himachal Pradesh, Madhya Pradesh, Madras, Mysore, Rajasthan and Uttar Pradesh.	2800 kg/cu m	770 to 2110 kg/sq cm
9	*Marble*	Andhra Pradesh, Gujarat, Madhya Pradesh, Mysore, Rajasthan and Uttar Pradesh.	2650 kg/cu m	720 kg/sq cm
10	*Gneisses*	Andhra Pradesh, Bihar, Gujarat, Madras, Maharashtra, Mysore, West Bengal.	2400 to 2690 kg/cu m	2100 kg/sq cm

8.4 Building Limes

8.4.1 Lime has been used in India as a material of construction from very ancient days. The manner in which ancient structures of pre-Mughal and Mughal periods have withstood the ravages of time bear irrefutable evidence to the durability of lime mortars. Lime is obtained by burning any form of limestone.

8.4.2 The following terms are defined:

1. *Quick lime*—A calcined material, the major part of which is calcium oxide in natural association with a relatively smaller amount of magnesium oxide, capable of slaking with water.

2. *Fat lime*—The lime which has high calcium oxide content and is dependent for setting and hardening solely on the absorption of CO_2 from the atmosphere.

3. *Hydraulic lime*—Lime containing small quantities of silica and alumina and/or iron oxide which are in chemical combination with some of the calcium oxide content, giving a putty or mortar which has the property of setting and hardening under water.

4. *Hyderated lime*—A dry powder resulting from treatment of quicklime with water enough to satisfy its chemical affinity for water under the conditions of its hydration.

5. *Lump lime*—Quick lime as it comes from the kilns

8.4.3 *Classification*—Building limes are classified as below:—

Class A:—Eminently hydraulic lime used for structural purposes.

Class B:—Semi hydraulic lime used for mortars for masonry work.

Class C:—Fat limes used mainly for finishing coat in plastering, white washing and with suitable admixture, such as surkhi or any other pozzolanic material to produce artificial hydraulic mortars.

Class A lime should be supplied in the hydrated form only while Class B and C limes can be supplied both as quick lime and as hydrated lime.

8.4.4 *Compressive Strength*
Lime Sand Mortar 1:3 (*by weight*)
Class A Lime (Min. strength)

17·5 kg/sq cm after 14 days.

28·0 kg/sq cm after 28 days.

Class B Lime (Min. strength.)

12·5 kg/sq cm after 14 days.

17·5 kg/sq cm after 28 days.

8.4.5 *Lime Putty*—Lime putty is a form of slaked lime and is commonly used in place of ordinary slaked lime in the preparation of mortars. It is prepared in the following manner:

Water is filled in a sufficiently large tank to which lime is gradually added. Lime paste is continuously stirred vigorously and lime is not allowed to get exposed above water. The mix should be stirred for at least 5 minutes after the boiling has stopped. The lime in a state of suspension is allowed to pass through IS Sieve 3·35 mm, and to flow into another tank at a lower level, where it is kept standing for at least 3 days before use. The lower tank is made of dry brick masonry with joints filled with sand. Part of the water is evaporated, part of it is soaked by ground and the remainder is removed leaving lime putty in a state of paste. Lime putty so formed should be kept wet till it is used. Putty obtained from hydrated eminently hydraulic lime should be used within 24 hours.

Putty obtained from hydrated semi-hydraulic or fat lime may be kept for three days after its preparation.

Putty prepared from hydrated non-hydraulic or fat lime may be kept for periods longer than 3 days if protected from drying out.

8.4.6 Lime is extensively used for masonry mortars for plastering and for preparing lime concrete.

8.5 Surkhi

8.5.1 Surkhi is made by grinding to powder burnt bricks, brick bats or burnt clay.

Lime surkhi which gives good results is made from clay to which 10 to 20 per cent quicklime has been added.

Surkhi should be ground to such a fineness that residue on IS Sieve 90 micron should not exceed 10 per cent by weight.

Surkhi is a good pozzolana when ground sufficiently fine and hence is used with lime to form a cementitious mixture. It is also used with portland cement to improve some of its properties, such as increased workability, plasticity and cohesiveness.

8.6 Mortars

8.6.1 Mortar is a mechanical mixture in varying proportions of a binding material like lime or cement and an inert material like sand, cinder and surkhi. Mortars are of four kinds:

(a) Mud mortar,

(b) Cement mortars,

(c) Lime mortars, and

(d) Cement lime mortars or composite mortars.

Mud mortar is extensively used in rural areas for brick work in superstructure. Investigations carried out at Building and Road Research Laboratory, Chandigarh have revealed that by adding 0·5 to 1 per cent coal tar by weight of soil, the resultant mortar becomes very much resistant to softening and erosive action of water. If the quantity of tar is increased to 3 per cent the mortar can also be used for pointing joints in the wall. To facilitate proper mixing of coal tar with mud, 10 per cent coal tar is replaced by kerosene oil.

Cement mortars can be mixed by hand but lime mortar and composite mortars should be ground mechanically. The object of grinding mortars is to crush particles of unslaked lime if any, so as to ensure their slaking, and to make an intimate mixture of the binding material and the inert material

Cement mortars are somewhat harsh and to improve their workability 10 per cent of the cement in cement mortar is often replaced by lime.

Mortars are used as a binding material in stone or brick masonry, or concrete and as a covering material to walls in the form of plaster to povide a smooth, hard and decorative surface. On account of its plastic nature, when green, it forms an excellent and even bed for irregular surface of stone and this results in equal distribution of pressure over it.

Proportions of Mortars for Various Purposes

(a) *Masonry in foundation and plinth*

(i) Cement mortar 1:6

(ii) Lime cement mortar 1:3:12

(iii) Where good quality lime and surkhi are available and sub soil water is not within 2·5 metres of foundation level the following lime mortars may be used:

1 lime: 3 sand
1 lime: 2 surkhi
or 1 lime: 1 surkhi: 1 sand

(iv) Where sub soil water is within 2·5 metres below the foundation level and the soil contains high percentage of soluble sulphates 1:1:6 cement lime mortar should be used

(b) *Masonary in super-structure*

(i) Cement mortar 1:6 or cement lime mortar 1:3:12, 1:1:8 for single and two storeyed constructions,

(ii) 1 lime: 3 sand

1 lime: 2 surkhi.

1 lime: 1 sukhi: 1 sand

(iii) For half brick walls use cement mortar 1:4 or cement lime mortar 1:1:6, and

(iv) For archwork—cement mortar 1:3.

(v) For single storey building lime coal ash mortar 1:3 can also be used.

(c) *Internal plaster*

(i) Cement plaster 1:6 (1 cement: 6 sand)

(ii) Cement lime plaster 1:2:9 (1 cement: 2 lime: 9 sand)

(iii) Lime plaster 1:2 (1 lime: 2 sand)

(iv) Lime surkhi plaster 1:2 (1 lime: 2 surkhi)

(d) *External plaster*

(i) Cement plaster 1:6 (1 cement: 6 sand)

(ii) Cement lime plaster 1:2:9 (1 cement: 2 lime: 9 sand).

8.6.2 *Soil Cement Plaster*—Investigations carried out by Building and Road Research Laboratory, Chandigarh have indicated that for plastering stabilized soil walls, soil cement plaster (1 part cement; 8 parts sandy soil-sand content 60 per cent, plasticity index 5 to 7) gives very satisfactory results.

8.6.3 *Water-Proof Mud Plaster*

8.6.3.1 Mud plaster is commonly applied to mud walls or walls made of kutcha sundried bricks in rural houses all over the country. The ordinary mud plaster consists of local soil and rotten straw over which a gobri leep is applied to give a finish and cover up the cracks. Such a plaster is no doubt very cheap. However, a great shortcoming of this plaster is that it cannot withstand the erosion caused by a few hours of continuous rainfall. Also the plaster being non-water-proof, repeated and alternate wetting and drying due to occasional rainfall and sun-shine causes the plaster to come off in flakes. Mud houses are thus damaged and need heavy repairs every year.

8.6.3.2 The properties of the ordinary mud plaster can be improved considerably by incorporating certain bituminous substances in it. The following three products have been found to be satisfactory after laboratory investigations and field trials:

1. *Janta Emulsion* (*H.R.P.*) marketed by Shalimar Tax Products (1935) Ltd.

2. *Central Road Research Institute Specification*—Four parts of bitumen 80/100 grade are mixed with one part of light creosote oil. The mixing is done by heating the bitumen to a temperature of 100°C and then adding to creosote oil. The mixture is stirred thoroughly and stored in metallic containers. In use it needs slight warming during winter.

3. *Central Building Research Institute Specification*—100 kg of bitumen 80/100 grade is mixed with 20 kg of kerosene oil. The mixing is done by heating the bitumen to a temperature of 100°C and then pouring into kerosene oil. The mixture is stirred thoroughly for 5 minutes. 1 kg of wax is then melted and mixed in the mixture.

The incorporation of these mixtures in the mud plaster increases its life to 5 to 6 years.

8.6.3.3 *Preparation of mud plaster*

(a) *Selection of soil*—The soil used should neither be too clayey nor too sandy. The clay content should be between 23—25 per cent and sand 40—45 per cent. It is generally sufficient to test the sand content only. For this purpose take a small tin and mark it into ten equal parts. Measure out a tin full of the soil sample and put it in a septrate vessel. Wash out the clayey portion of the soil by rinsing it with water a number of times. Dry the sand left behind. Measure the volume of the sand in the graduated tin. If the sand covers up to between the 4th and 5th mark then the soil contains about 45 per cent sand. Domat or Loam soil will do for this purpose.

(b) *Addition of bhusa*—Mix wheat straw or rice husk at the rate of 65 kg per cubic metre of soil and allow it to rot for about seven days in the presence of excess of water. During this period the puddle should be frequently worked up with spade or feet.

(c) *Mixing the emulsion or cutback bitumen*—An hour or two before the application of mud plaster add H.R.P. Janta Emulsion of cutback bitumen at the rate of 65 kg per cubic metre of dry soil used for making the plaster. The entire mix is then thoroughly worked up with feet or spade.

(d) *Application of the plaster*—After sprinkling water on the surface of the wall, the plaster is applied with a trowel, in a thickness of about 12 mm and the surface is then finished smooth. Occasional sprinkling of water on the plaster during hot weather will prevent cracks due to rapid evaporation.

(e) *Application of gobri leaping*—Hair cracks may develop after the plaster dries up. These can be closed by the application of a thin slurry, consisting of soil, cowdung and H.R.P. Janta Emulsion or cutback bitumen in the ratio of 15:5:1 by weight. If cowdung is not available, the concentration of bituminous mixture can be increased to 1½ times (soil bituminous mixture=10:1).

8.6.3.4 *Precautions*

1. Because of the difference in the inherent nature of the soil, plasters prepared with different soils behave differently. It is therefore, important to stick to the recommended specification. To see if the soil selected for plaster does not shrink abnormally, a small patch of plaster (mixture of soil and bhusa) is applied on the wall in thickness of 12 mm. This is allowed to dry and in case the cracking is excessive, requisite amount of sand should be added.

2. Any kind of haste or negligence while preparing cutback or during its mixing with the mud plaster greatly affects its efficiency. Proper care is, therefore, necessary to ensure that all ingredients are mixed well.

3. The walls should have damp-proof course at the foundation level to avoid rise of subgrade moisture.

4. The top of the wall should also be covered so that rain water may not enter the body of the wall.

5. Heated bitumen is added to kerosene oil and *not vice versa.*

6. The wall is wetted before applying plaster.

8.7 Concrete

8.7.1 *Mud Concrete*—Mud concrete is used in foundations. Brick or stone aggregate of 40 to 63 mm size is generally used. Mud and aggregate are mixed in the proportion of 1:3 by volume. Mud mortar should be prepared from stiff clay to the consistency of clay for brick making.

8.7.2 *Lime Concrete*—Lime concrete is used for foundations, for under layer of flooring and for terracing. Lime mortar prepared from 1 part of slaked lime and 1·5 parts of well ground surkhi should be added to brick or stone aggregate in the ratio of 1:2½. The aggregate generally used is of 40 mm gauge.

8.7.3 *Cement Concrete*—Cement concrete is used for foundations, flooring and for structural purposes. For foundations, lean concrete 1:4:8 or 1:5:10 can be used For structural work cement concrete of 1:2:4 proportion is normally used. For making 1:2:4 concrete for structural purpose 0·07 cu m of line aggregate, 0·14 cu m of coarse aggregate and 32 litres of water should be added to one bag of cement (containing 50 kg net cement).

8.8 Timber

8.8.1 Timber, like stone, is man's oldest building material and has been used considerably in rural housing. There is a general botanical classification of trees into two groups: Exogenous or outward growing and Endogenous or inward growing. The former is the class of trees which includes all the commercial timbers used for building purposes, and the latter includes the palms and bamboos of the tropics. The exogenous trees are divided into two main groups: Hardwoods and softwoods. Although used as vernacular names this division rests on a purely botanical distinction and not upon the hardness or softness of the timber, many hardwoods being softer than certain softwoods. The hardwoods belong to the dicotyledons characterised by broad leaves and bearing seeds enclosed in seed cases; the softwoods are the conifers or cone bearing trees characterised by needle or scale-like leaves, bearing seeds not enclosed in seed cases.

8.8.2 *Seasoning of Timber*—Seasoning of wood is the first step in the efficient utilization of timber, especially in this country, where the climatic conditions are very trying for wood work, and where several commercially important species of wood are hard, heavy and liable to develop defects while drying and in use, unless carefully seasoned. It should be emphasized that all timber, whether teak or other species, need proper seasoning in order to give satisfactory service. Seasoning should be regarded as an integral part of timber utilization. With the development of the timber industry and the increased use of Indian Teak and several other indigenous hardwoods (nonconifers), it has become imperative that adequate attention should be paid to the process of seasoning wood before use.

Freshly felled timber contains a large quantity of moisture, in many cases roughly 100 per cent based on oven-dry weight of wood; in some light timbers the quantity of water in green condition is even twice as much as the weight of wood substance (*i.e.* roughly 200 per cent). A well-seasoned piece of wood may on the other hand contain about 10 to 12 per cent moisture on an average. This would be in equilibrium with the atmospheric humidity in several parts of the country. This degree of seasoning is necessary for proper retention of shape and size of component parts of high class wood work. For rough work, and for outdoor uses, drying of timber, say up to 15 to 25 per cent moisture content, is considered enough, particularly because it makes preservative treatment easy and effective.

The process of drying timber, under more or less controlled conditions is called seasoning. During the course of the drying process, timber may develop defects and this is avoided by providing adequate protection against rapid drying conditions, such as sun and hot winds. Even seasoned timber should be stored under cover protected from direct sun and rain. Ordinarily, timber shrinks during drying, the main object of seasoning is to eliminate this shrinkage before using timber. Other advantages of drying timber are, increase of the strength in timber, reduction in weight for transport purposes, improvement in wood-working qualities, including gluing, painting and polishing and a certain degree of protection from attack by insects and fungus.

Seasoning Methods—Although there are two distinct methods in general use *viz*., air-drying and kiln-drying, air drying followed by a period of kiln-drying gives the most quick and satisfactory results.

Air Seasoning—Air drying consists of piling sawn timber into carefully arranged stacks in the open or in open sheds, so as to allow a flow of air to evaporate the moisture from the faces of timber. The stacks are formed on a level base about 30 cm above the ground and protected from sun and rain. See Fig. 4 to 8.

Air drying is a slow process and is dependent upon weather conditions. In general, it does not reduce moisture in the timber sufficiently for indoor use in moist climate. For these reasons the accelerated methods of kiln-drying are often employed either alternatively or additionally.

Kiln-Seasoning.—Kiln-seasoning consists of evaporating excess moisture by piling the timber in an enclosed chamber called a kiln, in which the temperature, humidity and air flow are controlled. These plants are suitable for seasoning timber on a mass scale.

8.8.3 *Preservation of Timber*—Timber is liable to deterioration from a number of causes amongst which are fungi, insects, and marine borers. Timber in a dry and well ventilated place or continuously submerged under fresh water will last indefinitely. When subjected to alternate dry and wet conditions, or used in dark, damp and unventilated position, it deteriorates very soon. Preservatives are used to protect timber against deterioration due to fungi and attacks of termites, borers and marine organisms.

Types of Preservatives

Type 1 (*Oil type*)—Coal-tar creosote with or without admixture with various grades of petroleumn or other suitable oils having high boiling point.

Type 2 (*Organic solvent type*)—Copper naphthenate, zinc naphthenate, pentachlorophenol, benzene hexachloride and pp. dichlorodiphenyl-trichloroethane (DDT).

Type 3 (*Water soluble "leachable" type*)—Zinc chloride, boric acid, borax, sodium fluoride, sodium pentachlorophenate and benzene hexachloride (dispersible powder).

Type 4 (*Water soluble "fixed" type*)—Copper-chrome-arsenic composition (copper sulphate 3 parts, sodium dichromate 4 parts, arsenic pentoxide 1 part), acid-cupric-chromate composition (chromic acid 1·68 parts, copper sulphate 50 parts, sodium dichromte 47·5 parts), chromated zinc chloride (sodium dichomate 1 part, zinc chloride 1 part), copperchrome-boric composition (copper sulphate 3 parts, sodium dichromate 4 parts, boric acid 1·5 parts), zinc-meta-arsenite (Zinc oxide 2 parts, arsenic trioxide 3 parts) and zinc chrome boric composition (zinc chloride 3 parts, sodium dichromate 4 parts, boric acid 1 part).

Types of Treatment

(a) *Surface application*—This is done either by brush, spray or dipping in the preservative solution for a short period. For this treatment, timber, if in rounds, is debarked thoroughly. For the oil type preservatives, the moisture content in timber should not be more than 14 per cent. With aqueous solution, a moisture content of 20 to 30 per cent is permissible. At least two coats should be applied; the second and subsequent coats should not be applied until the first has dried or soaked into the wood. Where practicable the treatment is done hot. Surface treatment has a limited scope, and is used mostly for treating material at site and for re-treatment of cut surfaces.

(b) *Soaking treatment*—In this treatment the timber is debarked thoroughly, and the treatment is carried out by submerging the timber in the preservative solution for a sufficiently long period until the required absorption of the preservative is obtained.

(c) *Hot and cold process*—In this process the timber is submerged in the preservative solution which is then heated to about 90°C and maintained at this temperature for a suitable period depending on the charge. It is then allowed to cool until the required absorption of preservative is obtained. During the heating period, the air in the timber expands and is ptrtially expelled; during cooling, the residual air in the timber contracts creating a partial vacuum which causes the preservative to be sucked into the timber.

This treatment also ensures sterilization of the timber against fungi and insects that may be present. In the absence of facilities for pressure treatment, this process is recommended for timber containing sapwood and easily treatable heartwood. With water soluble-fixed type of preservatives, however, there is a danger of precipitation of the chemicals at high temperatures and in contact with the extractives in timber. To overcome this difficulty two baths are use, the first containing water where the hot treatment is given, and the second the cold bath containing the preservative into which the timber is transferred immediately after heating.

(d) *Boucherie process*—With this process treatment of the sapwood of almost all green timbers with the bark on and of bamboos in green condition, soon after felling, can be carried out using any of the inorganic water-soluble preservatives. The treatment is carried out by attaching to both ends of a pole with bark on, a rubber hose connected to a reservoir containing the preservative solution and placed at sufficiently high level. The pole is held in an inclined position. Due to hydrostatic pressure the preservative displaces the sap in the timber.

Pressure Process—There are three pressure processes for preservative treatment of timber namely, Bethel Process, Lowry Process and Rueping Process. These processes require mechanized plant and are suitable if timber treatment on a large scale is to be carried out.

8.8.4 *Grouping of Structural Timbers*—So far only primary species of timber have generally been used for building construction purposes. As demand for timber is increasing and reserves are fast dwindling, it has become necessary to use secondary species of timber after suitable chemical treatment for durability.

In Table I species of structural timber are classified in three groups based on structural characteristics, namely, modulus of elasticity and modulus of rupture as follows:

SUPER—'E' greater than 126000 kg/sq cm
ft equal to 180 kg/sq cm or greater

STANDARD—'E' greater than 98000 kg/sq cm but equal to or less than 126000 kg/sq cm
ft equal to or greater than 120 kg/sq cm

ORDINARY—'E' greater than 56000 kg/ cm but equal to or less than 98000 kg/sq cm
ft equal to or greater than 85 kg/sq cm

Timbers of ordinary group are suitable for spans up to 6 metres, that of standard group for spans exceeding 6 metres but up to 12 metres and that of super group for spans exceeding 12 metres.

8.8.5 *Working Stresses*—Working stresses for Indian timber have been given in Indian Standard IS: 883-1961 "Code of Practice for Use of Structural Timber in Building."

8.9 Bammo

8.9.1 Bamboo constitutes one of the most versatile products of nature. By virtue of its ready availability, comparative cheapness, high strength-weight ratio and easy workability, it has continued to play a vital role in rural housing. India is one of the richest countries from the point of view of bamboo resources. The thickness of bamboos varies from reed size up to 20 cm and it is available in lengths up to 40 metres. Some Indian bamboos used for building construction have been listed below:—

Local Name	*Distribution*
Lilli	Assam, Naga Hills
Khnap, Uspar	Assam, West Bengal
Chevani	Southern and Western India.
Kata, Katas, Koto,	
Bihor, Bans, Dowga,	Throughout India
Balku, Baluka	Assam, Bihar, West Bengal
Pichle, Nan Bans	Lower Himalayas (Jammu to Assam)
Betua	Assam, West Bengal
Jati, Tulda	Do
Basni	Orissa, Bihar, cultivated throughout India
Latang	Assam, Bihar
Kokwa, Pecha	Assam, West Bengal
Pecha Kokwa	Assam, W. Himalayas
Wadah, Tiria	Assam, Sikkim
Medar, Salia, Salia Bans	Throughout India
Muli, Tarai	W. Bengal
Chiva	West Coast
Botantgi Bans, Washut	Orissa, Assam
Bijal, Tolli, Nal	Assam & E. Himalayas
Dullooa	Assam
Marlong	Assam

8.9.2 Bamboo is an excellent material for framework of houses in seismic areas. It is also used for foundations, flooring, walls, partitions, ceilings, roofing, doors and windows and drainage purposes. Because of its high tensile strength, bamboo has also been used as a reinforcement for concrete, but its bond strength is much less. Bamboos have also been used for manufacturing a variety of building boards.

8.9.3 Notwithstanding their outstanding characteristics, bamboos have got some positive shortcomings as well, which limit their fuller utilization in the field of building construction. The low durability of bamboo constitutes one of its most serious defects.

Another serious defect of bamboo as a constructional material is its extreme fissility. Except for certain thick walled bamboos, most bamboos, have a tendency to split easily. This prevents the use of normal joints or even the use of nails. Cutting a notch or mortice in a bamboo drastically reduces its ultimate strength. The only remedy is the use of nodes as places of support and joints and the use of lashing materials in place of nails.

8.9.4 *Preservative Treatment of Bamboos*—Bamboo being an organic material, starts decaying after sometime and

is also destroyed by insects and borers. Preservative treatment of bamboos is, therefore, essential. The following two compositions have been found to be useful and these can be conveniently prepared in the field.

1. *Copper-chrome-arsenic composition*—In 100 litres of water dissolve 3 kg of copper sulphate crystals, 4 kg of potassium dichromate and 1 kg of arsenic pentoxide and mix well.

2. *Copper-chrome-acetic acid composition*—In 100 litres of water dissolve 4 kg of copper sulphate crystals, 4 kg of sodium dichromate and 200 grams of acetic acid and mix well.

Preparation of Bamboos for Treatment—Depending on the method of treatment bamboos are prepared for treatment. For treatment by ordinary dipping method the bamboos are cleaned and cut into required sizes. At nodal points, holes are made.

For other methods, the bamboos along with their branches and leaves are used. They should be freshly cut. If for some reason, it is not possible to treat the bamboos immediately after their cutting, then they should be kept under water for two or three days immediately after cutting.

Methods of Treatment

1. *Treatment by dipping*—The easier method of treating bamboos is to dip them in the solution after removing their branches and leaves. But this method takes a considerable time. Alternatively freshly cut bamboos with branches and leaves are dipped in the solution. From the transpiration of moisture from the leaves and branches which remain in air, the preservative solution is drawn up into the bamboo clumps. For treatment it normally takes about two days, but it depends on the length, specie of the bamboos to be treated, and the climatic conditions. From the changing colour of the leaves, the progress of treatment is observed. After a little practice it can be easily seen when to stop the treatment.

2. *Boucherie process*—Freshly cut bamboos with leaves and branches are connected with tubes to drums containing the preservative solution as shown in Fig. 9.

The bamboos are placed at a slight incline, keeping the reservoir at a higher level so that the solution could flow from one end of the bamboo to the other. The higher the reservoir, the quicker is the treatment. Shortly after allowing the solution to flow, the sap starts flowing out of the lower end of the bamboo. This should be allowed to flow out for some time and then rejected. After some time, the preservative solution comes out slowly from the lower end of the bamboo. This should be collected and re-used for treatment after bringing the concentration of the solution to the required strength.

Improvement with Air Pump—If air-tight drums fitted with valves, etc are used as a reservoir of solution, a slight pressure can be applied with the help of an air-pump to increase the flow rate and to reduce the time required for treatment. The whole assembly is simple and inexpensive and by its use the treatment could be done within a few hours.

Drying of Bamboos—After treatment, the bamboos should be dried so that the moisture content is about 10 to 15 percent. Dried bamboos should be protected as far as possible from exposure to rain and dew.

Expected Service Life of Treated Bamboos—It is estimated that the expected service life of treated bamboos is 15 to 20 years; whereas that of untreated bamboos is 2 to 3 years. From this, it would be obvious that treatment of bamboo is very advantageous.

8.10 Grass and Palmyra Thatch

8.10.1 Grass and palmyra leaves are extensively used for roofing purpose in rural areas. Being organic materials, they are more susceptible to decay due to attack by fungi and insects and destruction due to fire. Preservative treatment is, therefore, essential to increase their life and make them fire proof. It is estimated that through preservative treatment, service life of grass thatch can be increased from 3 to 15 years and that of palmyra leaves from 2 to 12 years.

8.10.2 *Treatment for Protection from Decay Caused by Fungi and Insects*

(a) *Preparation of solution*—1 kg of copper sulphate and 1 kg of sodium dichromate are dissolved in 25 litres of water. 50 grams of acetic acid should then be added to this solution.

(b) The leaves or bundles of grass, loose, loosely tied together respectively should be dipped in the preservative solution. These should be turned over a little so that they wet on all sides.

(c) The grass thatch should be dipped in the solution for 6 hours while palmyra leaves should be dipped for 24 hours.

(d) Before using the grass or palmyra leaves they should be air-dried, so that their moisture content is around 15%. This helps in fixation of some of the chemicals so that they are not easily leached out by coming in contact with water.

8.10.3 *Treatment for Protection from Fire and Decay*

(a) *Preparation of solution*

3 kg of boric acid, 1 kg of copper sulphate, 5 kg of zinc chloride and 6 kg of sodium dichromate are dissolved in 100 litres of water.

(b) The thatch grass should be dipped in this solution for 32 hours and the palmyra leaves for 48 hours.

(c) The grass thatch or palmyra leaves should then be dried in air to about 15% moisture content.

8.11 Reed Board

8.11.1 Reed, a forest product, has been used in India and abroad for building work in rural areas for a number of years. Use of reeds in the form of building boards which are made of reeds firmly held together under slight compression by a number of wires running on both the sides, is an improvement over the traditional material. Reed boards can be manufactured on a wooden frame in rural areas at a very cheap rate. The thickness varies from 25 mm to 50 mm.

8.11.2 Reed boards can be used for the construction of houses in many ways. By using suitable frame work of wood battens, walls with reed boards can be constructed. These walls can be plastered with mud, lime or cement plaster. Similarly reed boards can be used for roofing purposes. However, reed boards are liable to attack by termites and are not suitable in areas where termite attack is very common.

8.12 Roofing Materials

8.12.1 *Country Tiles*—Country tiles are made on the potter's wheel. A hollow cylinder is first made which is cut into two pieces. After drying, the tiles are burnt in the potters' kiln. In Madhya Pradesh the shape of the country tiles is that of the blade of a spade. Country tiles are very weak and porous and have to be replaced frequently.

8.12.2 *Guna Tiles*—Guna tiles are hollow tapered burnt clay tiles. They are conical in shape with a diameter of 100 mm on the broader end and 75 mm at the narrower end, the thickness of the annular ring being 6 mm. These tiles are village products and can be produced on the potter's wheel. These are used for unreinforced low rise vaulted roofs.

TABLE I

GROUPING OF TIMBERS FOR STRUCTURAL USE

Species for Permanent Structures									Species for Temporary Structures		
First Choice						Second Choice			Non-durable and Non-treatable		
Naturally durable			Moderately durable or non-durable but easily treatable under open tank process			Moderately durable and non-treatable but whose treatability can be improved for small sizes (thickness up to 6 cm)					
Trade Name	Locality	Local Names	Trade Name	Locality	Local Names	Trade Name	Locality	Local Names	Trade Name	Locality	Local Names
1	2	3	4	5	6	7	8	9	10	11	12
A. GROUPSUPER											
Black Siris	Madhya Pradesh, Assam, Madras, Maharashtra, Uttar Pradesh, Orissa	kala siris (Hin), kurmuru (Pun), hihand, jotikoroi (Asm), koroi (Ben), kiachalom (Kol), srisi (Mar), Chichwa (MP), kaliosiras (Guj), bilkambi, godhunchi (Kan), chelavagai (Kan), karuvaka (Mal), karuvagai (Tam) chinduga (Tel)	Hollong	Assam	hollong (Assam)	Ballagi	Madras, Maharashtra, Mysore	bailige, balagi (Kan), vayal (Mal), putangali (Tam)	Padriwood	Assam, West Bengal, Maharashtra, Madras	paroli (Asm), husi (Kol), parar (Nep), patuli (Oriya), kandol (Guj), genasing, mukarti (Kan), kursing, pudoli (Mar), kaladri pathiri (Kan), padiri (Mal & Tam), isikirasi (Tel)
			Kusum	Madhya Pradesh, Bihar, Orissa, Maharashtra, Madras, Uttar Pradesh	kusum (Hin), sagada, sagodi (Kan), hosimb (kusumbh) (Mar), puvam (Mal & Tam), pulusari (Tel)	Dhaman	Kerala, Madhya Pradesh, Maharashtra, Madras, Bihar, Orissa	phalsa (Pun), gonyer (Kol), phalsa (MP), dadsal, thadsal (Guj & Kan), thadasalu (Kan), chadachi (Mal), thadachi (Tam), peddajana (Tel)			
			Ping	Assam	ping (Asm)						
Bullet-wood	Andamans	bakula, mugali (Kan), elengi (Mal), nanupala (Tam), pala (Tel), borsali, rayan (Guj), mugali (Kan), ranjana, wovali (Mar)	-								
Hopea	Mysore, Madras	bogimar (Kan), irumbogam (Mal), vellaigongu (Tam)									
Karung-Kongo	Madras										
Khair	Uttar Pradesh	khair (Hir), khoira (Asm), khaira (Oriya), kath (Kan), karangalli (Tam), sandra (Tel)									
Muses	Assam, Andamans, Madras, West Bengal, Mysore, Maharashtra	gangane (And), nahor (Asm), nageswar nagkesar (Ben), negeswar (Oriya), nagasampigi (Kan), churuli (Mal), nangal, nangu (Tam), nagkesari (Tel)									
Millis	Maharashtra, Madras, Mysore	naviladi, nevaladi (Kan), myladi (Mal), mayiladi (Tam), nemiliyadugu (Tel)									
Red Sanders	Madras	rakthachandanam (Kan & Mal), chemmaram (Tam), yerrasandanam (Tel)									
Sal	Uttar Pradesh, West Bengal, Bihar, Orissa, Assam	sakhu, sal (Hin), sarjam (Kol), raigala sargi (Oriya)									

TABLE I—*Contd.*

Species for Permanent Structures									Species for Temporary Structures		
First Choice						Second Choice			Non-durable and Non-treatable		
Naturally durable			Moderately durable or non-durable but easily treatable under open tank process			Moderately durable and non-treatable but whose treatability can be improved for small sizes (thickness up to 6 cm.)					
Trade Name	Locality	Local Names	Trade Name	Locality	Local Names	Trade Name	Locality	Local Names	Trade Name	Locality	Local Names
1	2	3	4	5	6	7	8	9	10	11	12
B GROUP—STANDARD											
Andaman Padauk	Andamans	padauk (And)	Babul	Maharashtra, Madhya Pradesh, Uttar Pradesh, Madras, East Punjab, West Bengal.	babul (Hin), kikar (Pun), babla (Ben), babul (Mar), babal, bawal (Guj), sali, jali, mashwel (Kan), karijali (Kan), karuvelam (Mal), karuvai (Tam), nallatumma (Tel).	Amoora	West Bengal, Assam	lalchini (And), amur (Asm), lali (Ben & Nep.).	Aini	Maharashtra, Madras, Mysore.	hebbalasu, hebhulsina (Kan), path-phanas (Mar), aini pilavu (Mal), ainipila, anjili (Tam).
									Axlewood	Uttar Pradesh, Madhya Pradesh, Maharashtra, Madras, Mysore, Bihar, Orissa, Andhra Pradesh.	bakli, dhaura (Hin), chhal (HP), dhao (Pun), kathal (Hin), hessel (Kol), banjhi (Nep), dhaw (Oriya), dhaura (Mar & MP), dhar-do, dhauro, dhavado dhavdo (Guj and Mar), dindal (Kan).
Benteak	Mysore, Kerala Maharashtra	nana (Guj & Mar), nandi (Kan), bende-ku, (Kan), venteak (Mal), bethe kku, venthekhu (Tam)				Bakul	Madras, Maharash-tra	khirni (MP)	Cinnamon	Assam, West Bengal, Madras.	gondsoroi (Asm), gundroi tejpat (Ben), malagiri (nep), risni (Kan), dalchini (Mar).
Bijasal	Madhya Pradesh, Mysore, Kerala, Madras, Maharashtra, Uttar Pradesh	piasal (Ben & Oriya) hid (Kol), bija (MP), beo (Guj), honne (Kan), bibla (Mar), venga (Mal), vengai (Tam), yegi (Tal),	Bahera	Uttar Pradesh, Madhya-Pradesh, Maharashtra Madras, Punjab	bahera (Hin), bhaira (Pun), bahera (Mar), baheda (Guj) tare, tari (Kan), vahela (Mar).	Dhaman	Uttar Pradesh, Madhya Pradesh, Bihar	phalsa (Pun) gon-yer (Kol), phalsa (MP), dadsal, tha-dsal (Guj & Kan), thadsalu (Kan), chadachi (Mal), thadachi (Tam), Pedda-jana (Tel)	Dhup	Madhya Pradesh, Maharashtra, Madras.	raldhup (Kan), gugul (Mar), kun-thrikka-payin (Mal), karapu, ka-rum, karunkungiliam (Tam).
Eucalyptus	Madras					Jamun	Maharashtra, Madras, Madhya Pradesh, Uttar Pradesh, West Bengal, Assam, Orissa.	jamun (Hin), jam-uk, (Asm), jam (Ben) kuda (Kol), jamu (Oriya), ja-mun (MP), jambu (Guj), nerlu (Ka-n), jambul (Mar), nerula (Kan), na-val (Mal & Tam), neredu (Tel).			
Gluta	Madras	devdari (Kan), chenku-runchi (Mal), senku-runji (Tam)									
Hill Mahua	Andamans										
Indian Red wood	Uttar Pradesh, Maharashtra, Madras, Mysore.	rohina (Ben), rohan (Hindi), rohini (Kol), rohini, sohan, suan (Oriya)	Black Chuglam	Andamans	kala chuglam (And).						
Irul	Maharashtra, Madras, Mysore.	kongra, taggan (Oriya) Saria (Mar), sau-riya (MP) jambe (Kan), jamba (Mar), jambe, tirwa (Kan), irul (Tam), konda, tangedu (Tel)	Casuarina	Madras, Maharashtra, Orissa. Andamans.	jhau (Ben), jhaun (Oriya), saru (Guj & Mar), calimara, galaimara (Kan), suru (Mar), kesarike (Kan), chulamaram (Mal), sav-ukku (Tam), chavuku, saravu (Tel).						

TABLE I—*Contd.*

Species for Permanent Structures									Species for temporary Structures		
First Choice						Second Choice			Non-durable and Non-treatable		
Naturally durable			Moderately durable or non-durable but easily treatable under open tank process			Moderately durable and non-treatable but whose treatability can be improved for small sizes (thickness up to 6 cm.)					
Trade Name	Locality	Local Names	Trade Name	Locality	Local Names	Trade Name	Locality	Local Names	Trade Name	Locality	Local Names
1	2	3	4	5	6	7	8	9	10	11	12
Kokko	Andamans, West Bengal, Madhya Pradesh, Assam, Maharashtra, Madras, Uttar Pradesh	siris (Hin), sarin, shrin (Pun), hirih (Asm), sirish (Ben), siris (Oriya), chichola (Mar), sirsul (Kan), siras, siris (Mar), bage (Kan), vaka (Mal), vagai (Tam), dirisinam (Tel)	Gurjan	Andamans, West Bengal, Assam, Madras, Mysore.	garjan (Asm), challane, kalpine (Kan), yennemara (Coorg), kalpayini, kalpine (Mal), enney, velayini (Tam).	Jutili	Assam	jutili (Asm).	East Indian Satinwood	Madhya Pradesh, Maharashtra, Madras	ghiria, behra, bhirra (Mar & MP), muragalu (Kan), porasu (Tam), bilga, billu (Tel)
									Ebony	Andamans	tupra (Kan), thumbi (Tam), tuki, tumiki (Tel)
									Hoom	Maharashtra, Madras	humb (Guj & Mar), woomb (Kan)
Piney	Madras, Mysore	yennamara (Kan), chukkana-payini (Mal), kolavu (Tam)	Harda	Maharashtra, Madhya Pradesh, Madras.	hararh, harr (Hin), harr (Pun), allale (Kan), pulincakku (Mal), colaippakku, illagucam, kadukkai (Tam), karakkai (Tel).	Kindal	Maharashtra, Madras	honal (Kan), kindal (Mar), honagalu, honal, hunal (Kan), pillamarudu (Mal & Tam), nallapulaga (Tel).	Karal	Assam	
Pussur	West Bengal								Lendi	Assam, West Bengal, Madhya Pradesh, Uttar Pradesh, Maharashtra, Mysore.	asidh, dhauri, sida (Hin), mechi (Asm), sidha (Ben & Oriya), gara sekre (Kol), buri-dhamero (Nep), lendia senha (Mar), kaliasaja, lendia (MP), bondaro (Guj), channangi (Kan), channangi (Kan & Tel), nanagu (Mal), peikadukkai (Tam)
Sal	West Bengal, Bihar, Orissa, Assam, Madhya Pradesh	sakhu, sal (Hin), sarjam (Kol), raigala, sargi (Oriya)	Karani	Madras, Kerala, Maharashtra, Mysore.	mulluchakka (Mal), ainipila, vedipila (Tam).						
						Yon	Orissa	garahessel (Kol), phansi (Oriya).			
Teak	Madhya Pradesh, Madras, Maharashtra, West Bengal, Orissa, Mysore	sagoon (Asm), shegun (Ben), sagwan (Hin), saguan (Oriya), sagon (MP), sag (Guj & Mar), tegu (Kan), saguvain, thega, thekinamra (Kan), theku (Mal & Tam), teku (Tel)	Mundani	Madras, Madhya Pradesh, West Bengal, Mysore.	mandane (Nep), belanji (Kan), kuranyan, malaveppu (Mal), malam konnai (Tam).	Palli & Tali	Madras, Mysore, West Bengal, Assam	hadasale (Kan), palvadinjan (Tam).	Machilus	West Bengal	
									Red bombway	Andamans	
									Sundri	West Bengal	
									White Chuglam	Andamans	safed chuglam (And)
									Banati	Mysore, Madras, Maharashtra	balpale, benate (Kan), karuka venkatavu (Mal), vengottai (Tam)
White Cedar	Madras, Mysore	bilidevdari (Kan), vella gil (Mal & Tam)	Oak	East Punjab, Uttar Pradesh, West Bengal, Assam, Kashmir.	buk (Ben), phalant (Nep).				Bel	Uttar Pradesh	bel (Hin)
			Sain	Bihar, Uttar Pradesh, Maharashtra, Madras, West Bengal, Orissa.	asna, sain (Hin), aisan (Pun), ain, sadar, saj (MP), karimatti, matti (Kan), ain, sajad (Mar), banappu (Kan), karumarudu (Mal), karimarudu, matti (Tam), nallamaddi (Tel).						
C. GROUP—ORDINARY											
Anjan	Maharashtra, Madhya Pradesh, Madras, Mysore	anjan (Mar), eppa (Tel), karacha, karachi (Kan), acha (Mal & Tam), yepi (Tel)	Arjun	Madhya Pradesh, Maharashtra, Madras.	arjun (Hin), kowa (Kol), arjuna (Oriya), bilimaddi, thoramatti (Kan), vellilava (Mal), vellamaruthu (Tam), tellamaddi (Tel).	Anjili	Kerala				
						Chaplash	Assam, West Bengal, Andamans	tuangpeine (And), cham, sam (Asm), chapalish (Ben), Latore (Nep.).			
Cypress	Uttar Pradesh, East Punjab	devidiar, leuri (Hin), saro (HP), surai (Kumaon)	Bonsum	Assam, West Bengal.	angari (Nep).						
						Iruppai	Kerala				
						Kadukkal	Kerala				

TABLE I—*Contd.*

Species for Permanent Structures									Species for Temporary Structures		
First Choice						Second Choice			Non-durable and Non-treatable		
Naturally durable			Moderately durable of non-durable but easily treatable under open tank process			Moderately durable and non-treatable but whose treatability can be improved for small sizes (thickness upto 6 cm)					
Trade Name	Locality	Local Names	Trade Name	Locality	Local Names	Trade Name	Locality	Local Names	Trade Name	Locality	Local Names
1	2	3	4	5	6	7	8	9	10	11	12
Deodar	East Punjab, Uttar Pradesh, Himachal Pradesh.	deodar (Hin), kelo, kelon (HP), diar (Pun).	Chikrassy	Assam, Madras, Mysore	yin-mabin (And), bogapoma (Asm), lal-devdari (Mar), urulu (Kan), malaveppu (Mal), madagfrive-mub (Tam).	Kasi	Bihar, Orissa, Maharashtra Uttar, Pradesh, West Bengal.	gondni, khaja, khaju (Hin), ghaj (HP), kuhir (Asm), Kaka (Kol), gayo (Nep), kosi (Oriya), guje, komangi (Kan), mulluvenga (Mal), mulvengai (Tam), koramanu (Tel)	Bishopwood	Assam, West Bengal, Maharashtra, Madras	ye padauk (And), kainjal (Ben & Nep), milimara (Kan), bok (Mar), cholavenga (Mal), cholavengai, malachadayan (Tam).
									Champ	Assam, West Bengal	sopa (Asm), champa (Ben & Oriya).
									Chillauni	West Bengal, Assam	gogra, makrisal (Asm).
									Domsal	Uttar Pradesh	
Gamari	West Bengal, Assam.	gamari, gamhar, khamhar (Hin), gumhar, kumhar (Pun), yamane (And), gomari (Asm), gumhar, (Ben), kasmar (Kol), khamari (Nep), gambhari (Oriya). siwan (MP), shivani, shiwan (Guj & Mar), kul imara (Kan), kumulu, shivane (Kan), kumilu (Mal), kumil (Tam), gummadi (Tel).	Chir	Uttar Pradesh, East Punjab, Jammu & Kashmir	chir (Hin), chil (Pun).	Poon	Maharashtra Madras, West Bengal	surhonni (Kan), goja, salhonne, surahonne (Kan), punna (Mal), kathupinnai (Tam)	Ebony	Madhya Pradesh, Maharashtra, Madras, Orissa, Uttar Pradesh	abnoos (Hin), kend (Ben), abnoos, kendu (Hin), tiril (Kol) bandardima (Asm), losuni (Ben), tendu tumri (MP),tamruj, timbervo, timasu (Guj), balai (Kan), temburni (Mar) tupra (Kan), thumbi (Tam), tuki, tumki, (Tel)
									Fir	Jammu & Kashmir, Uttar Pradesh, East Punjab.	morinda (Hin), pand, rai tosh (HP), partal (Pun).
Rose wood	Madras, Madhya Pradesh, Maharashtra, Bihar, Orissa, Mysore.	satisal (Ben), kiri (Kol),sissu (Oriya), shisham (MP), shisham (Guj & Mar), biti (Kan), veeti (Mal), itti jittegi (Tel).	Civit	Assam		Pyinma or Jarul	Andamans, Assam, West Bengal	pyinma (And), ajhar (Asm), gara sekre (Kol), panipatuli (Oriya)	Garuga	Uttar Pradesh, Madhya Pradesh, Madras, Maharashtra	ghoghar, kaikar, karapat (Hin), kakad (Mar), ghoghar (MP), karapati (Guj), kurak (Kan), godda, halabolagi (Kan), annakara (Mal), karuvembu (Tam).
Irul	Kerala, Madras, Mysore, Assam, Maharashtra.	kongra, tangan (Oriya) suria (Mar), sauriya (MP), jambe (Kan), jamba (Mar), tirwa (Kan), irul (Tam) konda tangedu (Tel).	Dillenia	West Bengal, Assam	zinbyun (And), ottenga (Asm), chalta, tartari (Ben), panchphal (Nep), rai (Oriya), kanagola (Kan), karmal (Mar).	Budrakshi	Madras, Maharashtra		Gokul	Assam, West Bengal	borpat (Asm), ghoranim, mahanim (Hin), mahalo (Oriya).
						Pullamarudu	Kerala		Kaunghmu	West Bengal	
									Keora	West Bengal, Maharashtra.	keowra (Ben)
Jack	Madras, Maharashtra.	kathal (Hin), kanthal (Hin), rukkathar (Nep), panas (Oriya), phanas (MP), phanas (Guj & Mar), halasu, halasin (Kan), alasua, halasu (Kan), pilavu (Mal), pila (Tam), panasa (Tel.)	Haldu	Maharashtra, Uttar Pradesh, Madras, Mysore, Assam, Orissa, Bihar, Madhya Pradesh	haldu (Hin), taraksopa (Asm), rangkat (Ben), karam (Hin), kumbha (Kol). kuruma (Oriya), haldu (Mar), karam (MP), yettagga (Kan), bimbu (Mal), kadambari, manjaka dambai (Tam), bandaru (Tel).	Sissoo	East Punjab Uttar Pradesh, West Bengal, Assam, Bihar Andamans	shisham (Hin), tahli (Pun).	Lampati	Assam, West Bengal	myauk-myo (And), khokan (Asm).
									Machilus	Madras, Maharashtra, Mysore, Kerala.	gulmav, gulum (Kan), poswa (Mar), gulamavo, gulmao (Kan), uravu (Mal), kolamavu, kolarmavu (Tam).
									Makai	Assam ‖	makai (Asm).
						Thitwin					
kongu	Kerala.		Hathipaila	Uttar Pradesh, West Bengal, Maharashtra	kanak-champa, mayengi (Hin), later (HP), hathipolia (Asm), bailo, muckhukenda (Oriya).						
Kumbhi	Maharashtra, Madras, Uttar Pradesh, Madhya Pradesh.	kumbhi (Asm & Ben), kambi (Hin), kaval (Kan), kumbhi, kumbia (Mar).	Hollock	Assam, West Bengal	panisaj (Nep).						
Lakooch	Uttar Pradesh	lakooch (And), dahua (Ben), dao (Kol), vate (Kan).	Indian Chestnut	West Bengal, Assam	hingori (Asm).						

Species for Permanant Structures									Species for Temporary Structures		
First Choice						Second Choice			Non-durable and Non-treatable		
Naturally durable			Moderately durable or non-durable but easily treatable under open tank process.			Moderately durable and non-treatable but whose treatability can be improved for small size (thickness up to 6 cm).					
Trade Name	Locality	Local Names	Trade Name	Locality	Local Names	Trade Name	Locality	Local Names	Trade Name	Locality	Local Names
1	2	3	4	5	6	7	8	9	10	11	12
Mahua	Madhya Pradesh, Madras, Maharashtra	mohwa, (Hin), madkam (Kol), Mahula (Oriya) mahua (Mar), mohwa, (M.P.).	Kadam	Assam, West Bengal, Mysore, Andaman	sanko (Kol), kadamba (Oriya), attuthekku, kadambam (Mal), (Kola), aiyila, vellakadam (Tam).				Mulberry	East Punjab, West Bengal, Assam.	shahtut (Hin) & (Pun), tut (Pun).
Neem	Uttar Pradesh, Madhya Pradesh	neem (Hin)	Kail	Jammu & Kashmir, East Punjab, Uttar Pradesh.	kail (Hin).				Palang	Maharashtra, Madhya Pradesh.	
Sandan	Madhya Pradesh, Maharashtra	panan, sandan, tinnas, tinsa (Hin), sannan, (Pun), bandhan, pandhan (Hin), ruta (Kol), telus (Dangs) tanach (Guj), karimuttal (Kan), tewas (Mar).	Kaim	Madhya Pradesh, Uttar Pradesh, Orissa, Bihar, Madras, Maharashtra	kalam, phaldu (Hin), guri (Hin), hamsabeti (Kol), mitukunia (Oriya), kalam (MP), kalam (Guj), kadawar kan, kaddam, kalamb (Mar) kadamba, vimbusiraka dambu (Mal), nedunrai, nirkadambai (Tam).				Pedunar	Madras, Maharashtra	
Sissoo	Uttar Pradesh, East Punjab, West Bengal, Assam, Bihar.	sisham (Hin), tahli (Pun).							Ruktamara	Madras, Maharashtra, Mysore.	
Teak	Madras, Madhya Pradesh, West Bengal, Orissa, Mysore, Maharashtra	sagoon (Asm), shegun (Ben), sagwan (Hin), saguan (Oriya) sagon (MP) sag (Guj & Mar), tegu (Kan), saguvain, thega. thekinmara (Kan), theku, (Mal & Tam), teku (Tel).	Kanju	Uttar Pradesh	kanju, papri (Hin), kumkar, rajain (Pun), anjan (Ben), chilbil, dhauranjo (Oriya), thapsi (Kan), aval (Mal), ayili (Tam).				Sakayranji	Madhya Pradesh, Bihar, Orissa, Maharashtra, Madras.	
			Mango	Throughout India	am (Hin), amb (Pun), am (Asm), uli (Kol), amba (Oriya), amba (Mar), mavu (Kan), mamaram (Tam), mamidi (Tel).				Salai	Maharashtra, Madhya Pradesh, Orissa, Bihar, Madras, Uttar Pradesh, Rajasthan.	salai (Hin), shala (Pun), salga (Hin), Salai (Mar), salga, salia (MP), saledi (Guj)
			Padriwood	Assam, West Bengal, Madras, Maharashtra	paroli (Asm), husi (Kol), parari (Nep), patuli (Oriya), padar (MP), kandol (Guj), genasing, mukarti (Kan), kursing, pudoli (Mar), kaladri, pathiri (Kan), padiri (Mal & Tam), isikirasi (Tel).				Spruce	Jammu & Kashmir East Punjab, Uttar Pradesh.	partal, rai (Pun).
			Toon	Uttar Pradesh, West Bengal, Assam, Maharashtra, Madras, Mysore.	tua (Hin), jatipoma (Asm), katangai (Kol), tuni (Nep), mahalimbo (Oriya), biligandhagiri (Kan), devdari (Mar), gangadhagerige (Kan), chuvannagil (Mal), malavembu (Tam), galimanu (Tel).				Vellapine	Maharashtra, Madras, Mysore	gugle, madidhupa, paini (Kan) dhup, kaidhupa (Kan), payin, vellakundrikam, vellapayini (Tam).
			White Siris	Uttar Pradesh, West Bengal, Assam, Madhya Pradesh, Maharashtra.	safed siris (Hin), sit (And), korori (Asm & Ben), tenthra (Kol), dhala sirish (Oriya), kinhai (Mar), gurer (MP), karangro (Guj), bellati (Kan), kilai, kinhai (Mar), salvagai (Kan), vellavaka (Mal), velvagai (Tam), tella chinduga (Tel).				Walnut	Jammu & Kashmir, Uttar Pradesh, East Punjab.	akhor, akhrot, khor (Hin).

8.12.3 *Allahabad and Mangalore Pattern Tiles*—These are clay roofing tiles of the interlocking type and are characterized by their specific shapes. These tiles are machine pressed from well prepared clay and are carefully burnt in kilns.

8.12.4 *Cement Tiles*—In places where good quality earth for making clay roofing tiles is not available, cement tiles can be used. These are made from 1:3 cement sand mortar and are machine pressed.

8.12.5 *Pre-cast Doubly Curvey Cement Concrete Roofing Tiles*—These tiles have been developed by the Central Building Research Institute, Roorkee. The tiles are of square shape 68·5 cm × 68·5 cm. The thickness is 20 mm and the central rise is 40 mm. Plain cement concrete 1:2:4 (with 10 mm aggregate) is used for casting the tiles without any reinforcement. Each tile weighs about 27 kg.

Casting of the Tile

1. *Wooden frame*—The frame is made of wooden scantlings, 75 mm deep, the inner dimensions being 61 cm x 61 cm and outside dimension being 73·5 cm × 73·5 cm. This frame is provided with two handles on each side to facilitate handling. Headless nails are driven alround the frame on all the four external vertical faces.

2. A piece of medium quality hessian cloth is stretched across the wooden frame and fastened to headless nails provided in the frame.

3. *Wooden mould*—A wooden mould 68·5 cm. x 68·5 cm internally and 73·5 cm × 73·5 cf externally and 20 mm deep is made out of wooden scantlings and is used for casting the tile over the wooden frame covered with hessian cloth.

4. A masonry paltform 61 cm×61 cm×75 mm is made on the ground and the wooden frame with hessian cloth is placed over the platform so that the hessian cloth rests over the platform.

5. Cement concrete consisting of 1 part cement, 2 parts coarse sand and 4 parts hard stone grit (with 10 mm aggregate) is poured into the mould and compacted flush with the mould. The surface is troweled to obtain an even finish.

6. The frame along with the wooden mould is then lifted off the masonry platform and supported on bricks so as to leave the tile free within the support. The hessian cloth sags about 40 mm and the tile assumes the required shape.

7. As a result of the sag a crack is created around the edges or at the point where the curve starts which is filled with concrete and final smoothening is done.

8. The tile is allowed to remain in the mould for 24 hours after which setting of the tile is tested by pressure of thumb nail. This time is generally sufficient in good weather, but it may take a longer time in rainy or cold weather.

9. The set tiles are taken out and are cured for 8 to 10 days.

10. After curing, the tiles are stacked under cover for 15 days to allow shrinkage to occur.

8.12.6 *Galvanized Iron Sheets*—Corrugated galvanized iron sheets are available in the following thickness:

0·63 mm, 0·80 mm. 1·00 mm. 1·25 mm and 1·60 mm.

8.12.7 *Corrugated Asbestos Cement Sheets*—Asbestos Cement Sheets are extensively used for roofing purposes. There are two types of asbestos cement sheets, corrugated and semi-corrugated with the following characteristics:

1. *Pitch of corrugation*
   - Corrugated — 146 mm
   - Semi-corrugated — 338 mm
2. *Depth of corrugation*
   - Corrugated — 48 mm
   - Semi-corrugated — 45 mm
3. *Nominal Thickness*
   - 6 mm   7 mm
4. *Length*
   - 1·5, 1·75, 2, 2·25, 2·5, 2·75, and 3 metres.
5. *Overall width*
   - Corrugated — 1050 mm
   - Semi-corrugated — 1100 mm

8.13 Flooring Tiles

8.13.1 Clay flooring tiles were originally manufactured in Mangalore, but are now being produced on a large scale in Malabar, Cochin, Madras, Calicut and other places. These tiles are machine pressed and are available in following sizes:

15 cm x 15 cm x 18 mm
20 cm x 20 cm x 20 mm
22.5 cm x 22.5 cm x 22 mm

8.14 Development and Production of Building Materials on Co-operative Basis

8.14.1 Building materials are the weakest link in any scheme of rural housing, as nearly 70 per cent of the cost of a building is attributed to the materials. For the success of rural housing schemes, it is essential that the materials are produced locally on a co-operative basis so that the cost of transporting materials over long distances is saved. Local production of materials also gives employment to the villagers, thereby improving their economic conditions which is so very essential for the success of rural housing schemes.

8.14.2 Brick being the principal building material, can be produced by co-operative brick kilns. One brick kiln can supply the demands of neighbouring 10 to 12 villages. Results obtained in Uttar Pradesh in this respect are very encouraging. During 1957, nearly 772 brick kiln co-operatives were functioning in U.P. In these co-operatives nearly 55000 persons were employed and they produced 97 crore bricks costing Rs. 1·95 crores. It has been found that one unit of co-operative could produce economically 20 lakh bricks annually.

8.14.3 Similarly co-operatives could produce flooring and roofing tiles, precast R.C.C. beams, tiles, door and window frames, sanitary units, reed board and other products. The co-operatives functioning in village Chinhat in Uttar Pradesh and village Rao in Madhya Pradesh are examples of what can be achieved by these co-operatives.

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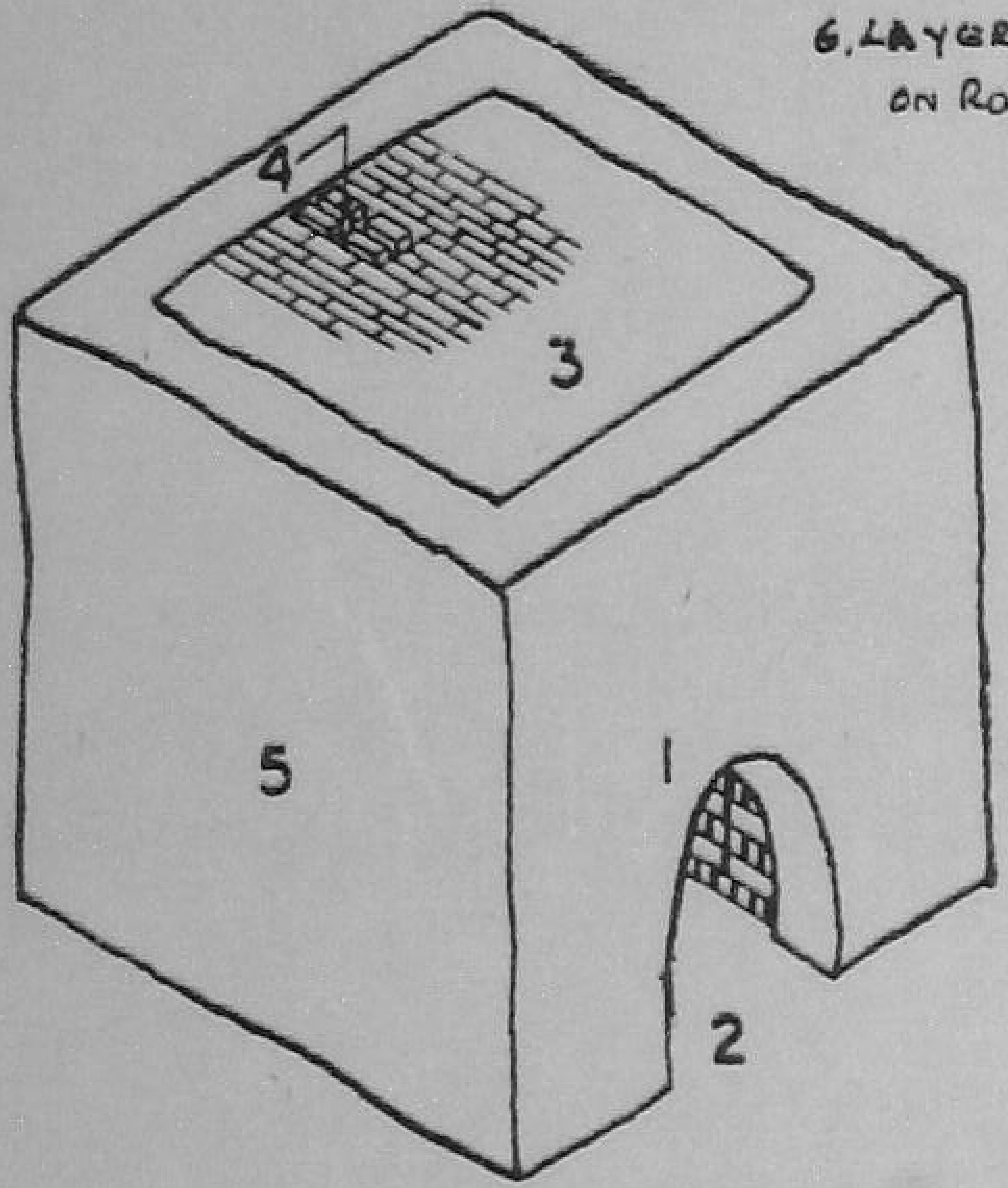
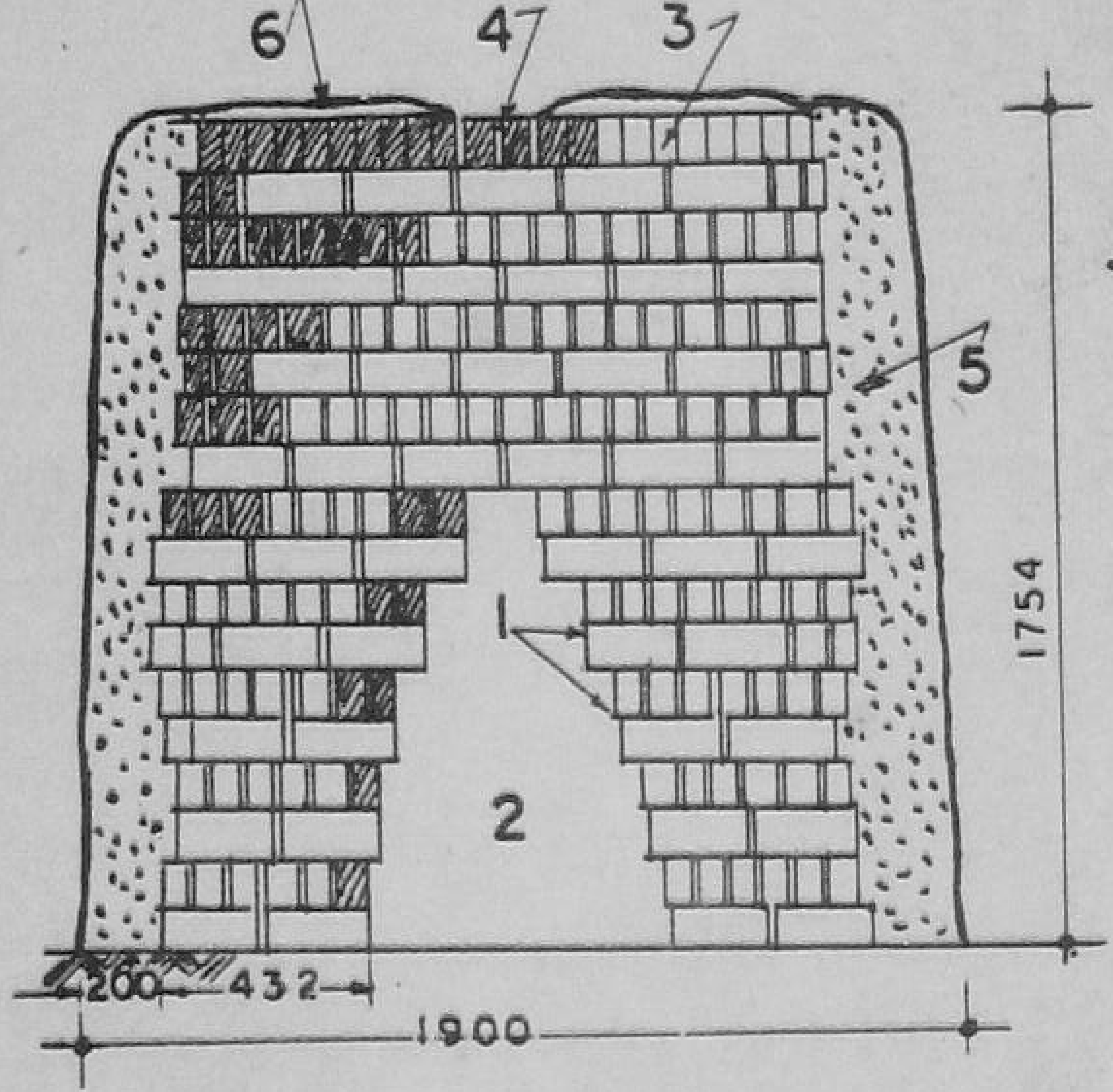
Buildings Organisation.

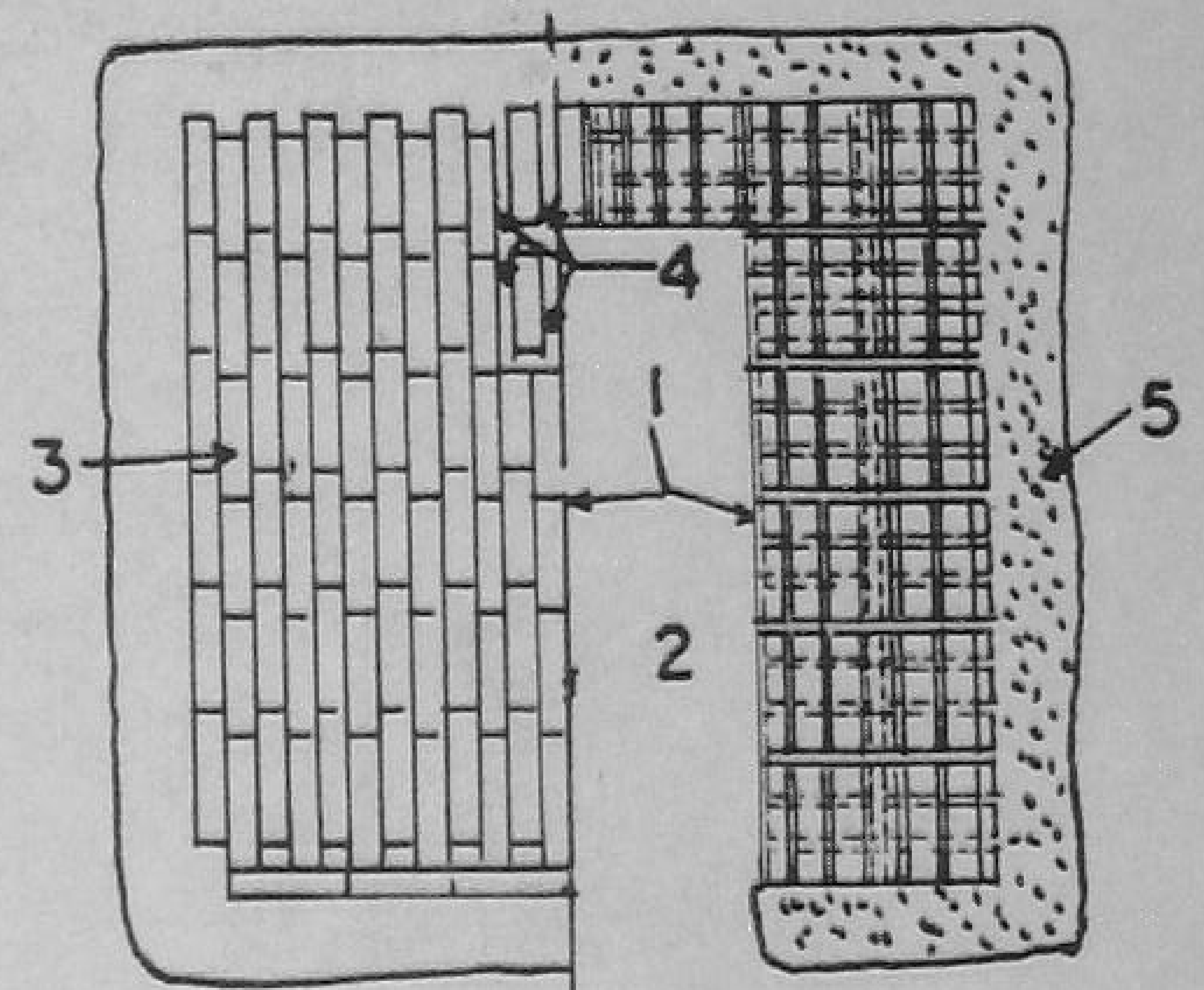
1. BRICKS TO BE BURNT.
2. PLACE FOR FIRE
3. CLOSELY PACKED BRICKS TO FORM ROOF
4. AIR SPACE BETWEEN FOUR BRICKS.
5. LAYER OF SOIL OVER WALLS OF KILN
6. LAYER OF SOIL ON ROOF OF KILN.



COMPLETE VIEW OF TEMPORARY KILN



HALF CROSS SECTIONAL ELEVATION OF KILN.

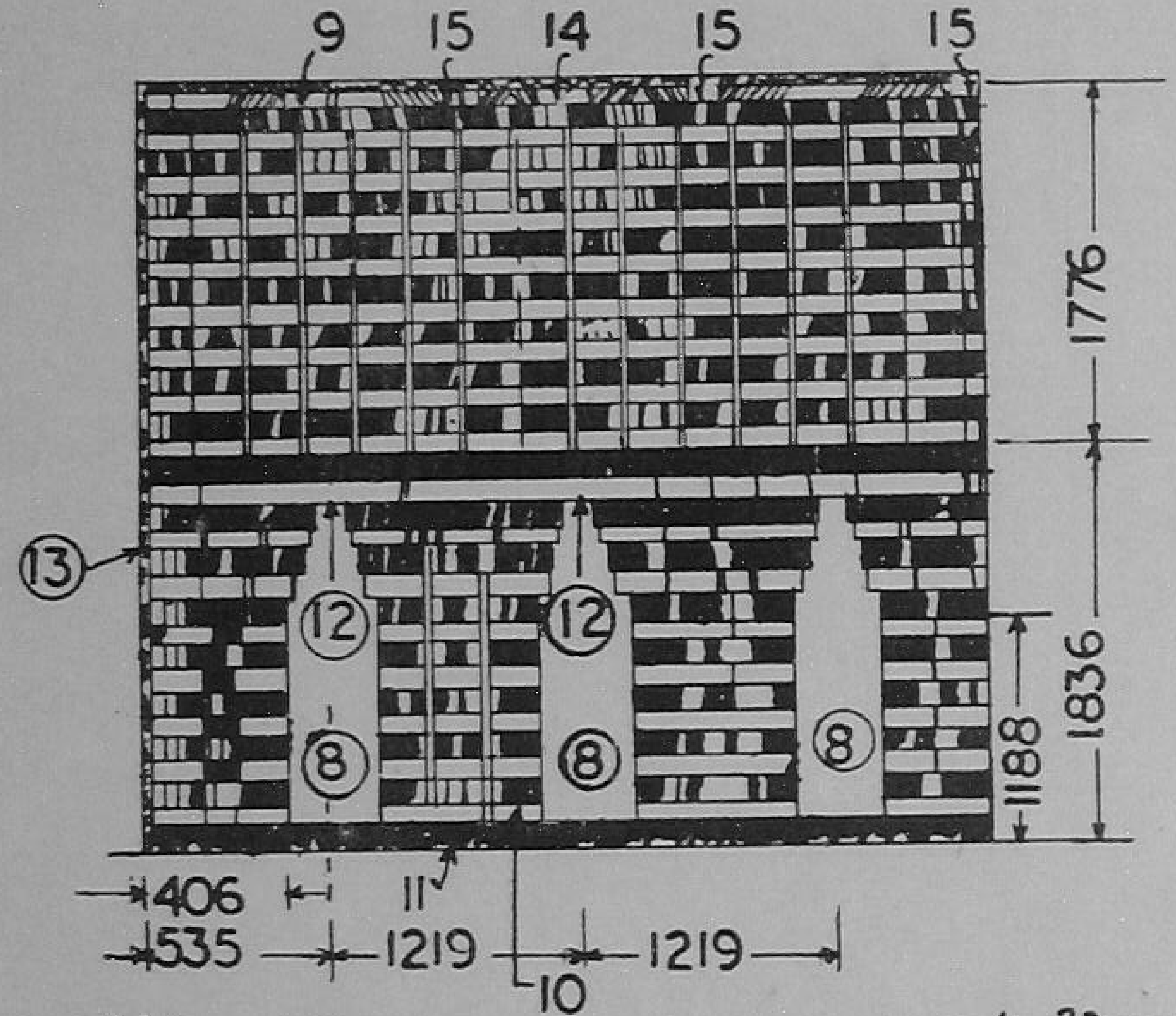


HALF SECTIONAL PLAN

FIG. 1

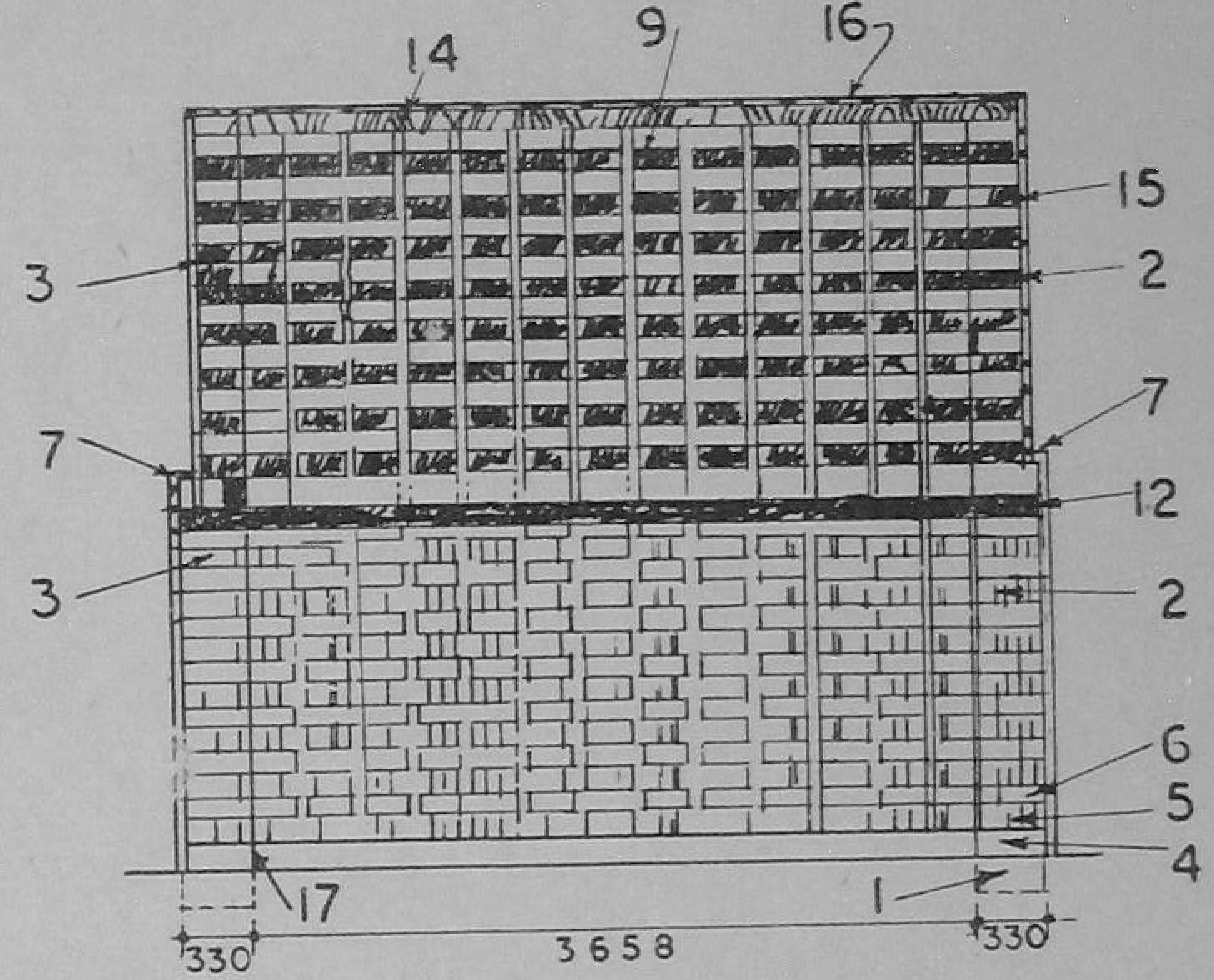
FIG. 2

SECTIONAL VIEW OF KILN.

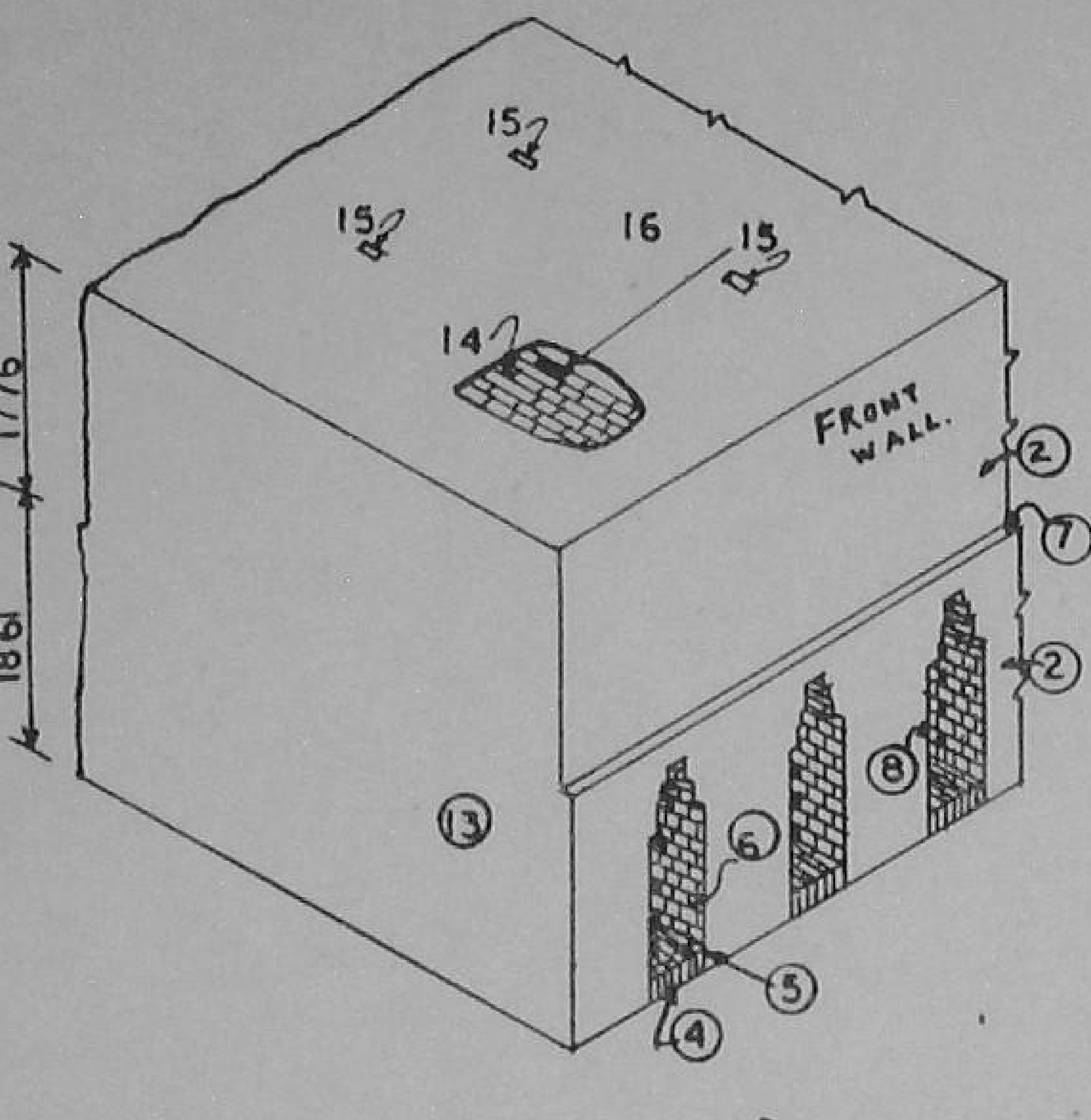


(1) Foundation; (2) Front permanent wall 330 mm thick upto 1800 mm and 230 mm above. Total height of wall 3660 mm. (3) Back permanent wall constructed similar to front wall. (4) As shown in sketch 'A', first layer of brick in wall. (5) Second layer of brick in wall. (6) Third layer of brick in wall.

SECTIONAL FRONT ELEVATION OF KILN.



(7) Thickness of wall 230 mm from here (8) Space for supply of fuel (9) Heap of bricks for burning (10) Arrangement of first row. (11) Second row (12) Arrangement of bricks to form heap upto top of kiln to form roof (13) Mud cover on walls (14) Roof (15) Holes for flue (16) Mud cover on roof (17) Kiln inside surface.



COMPLETE. VIEW OF PERMANENT KILN.

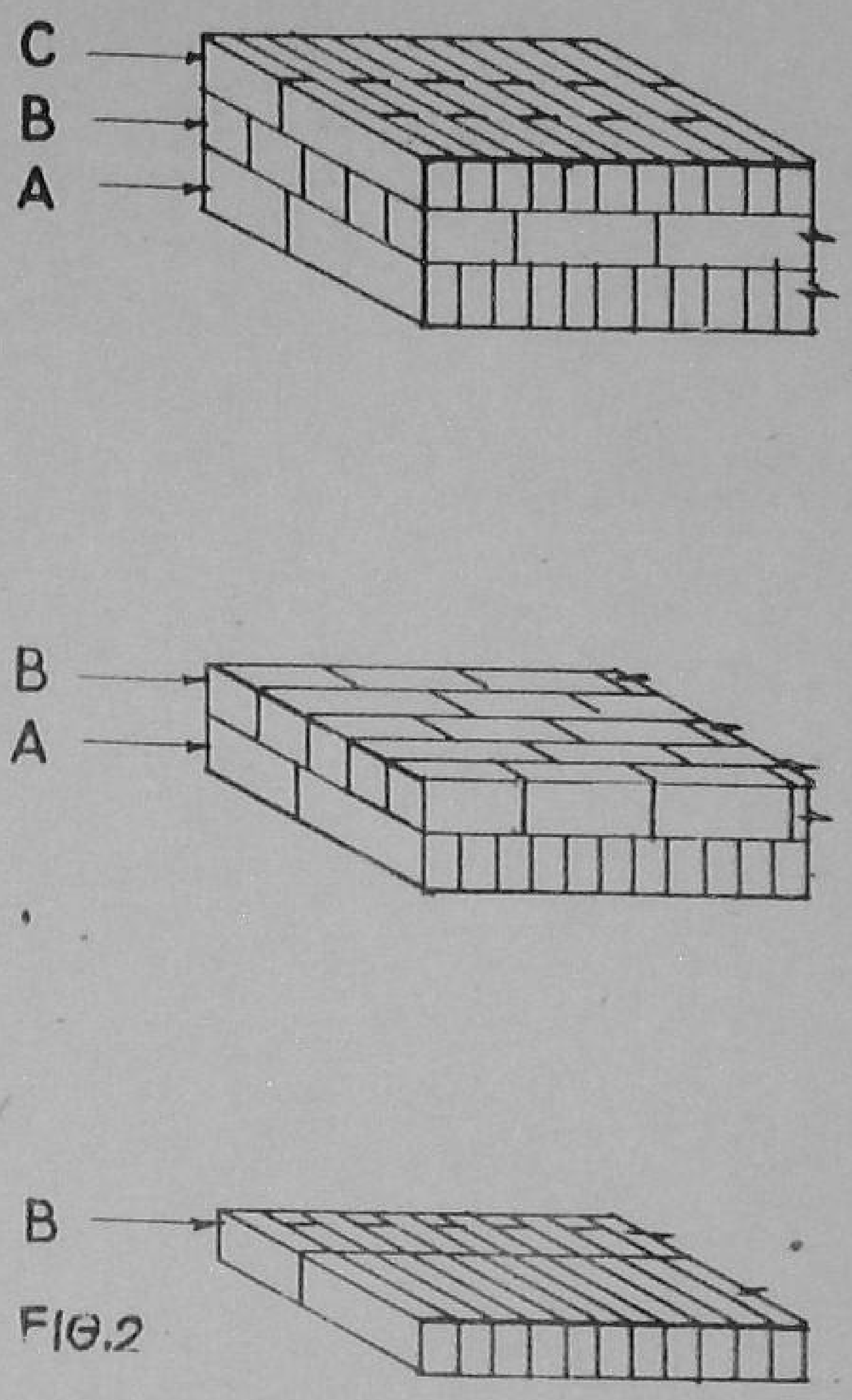


FIG.2

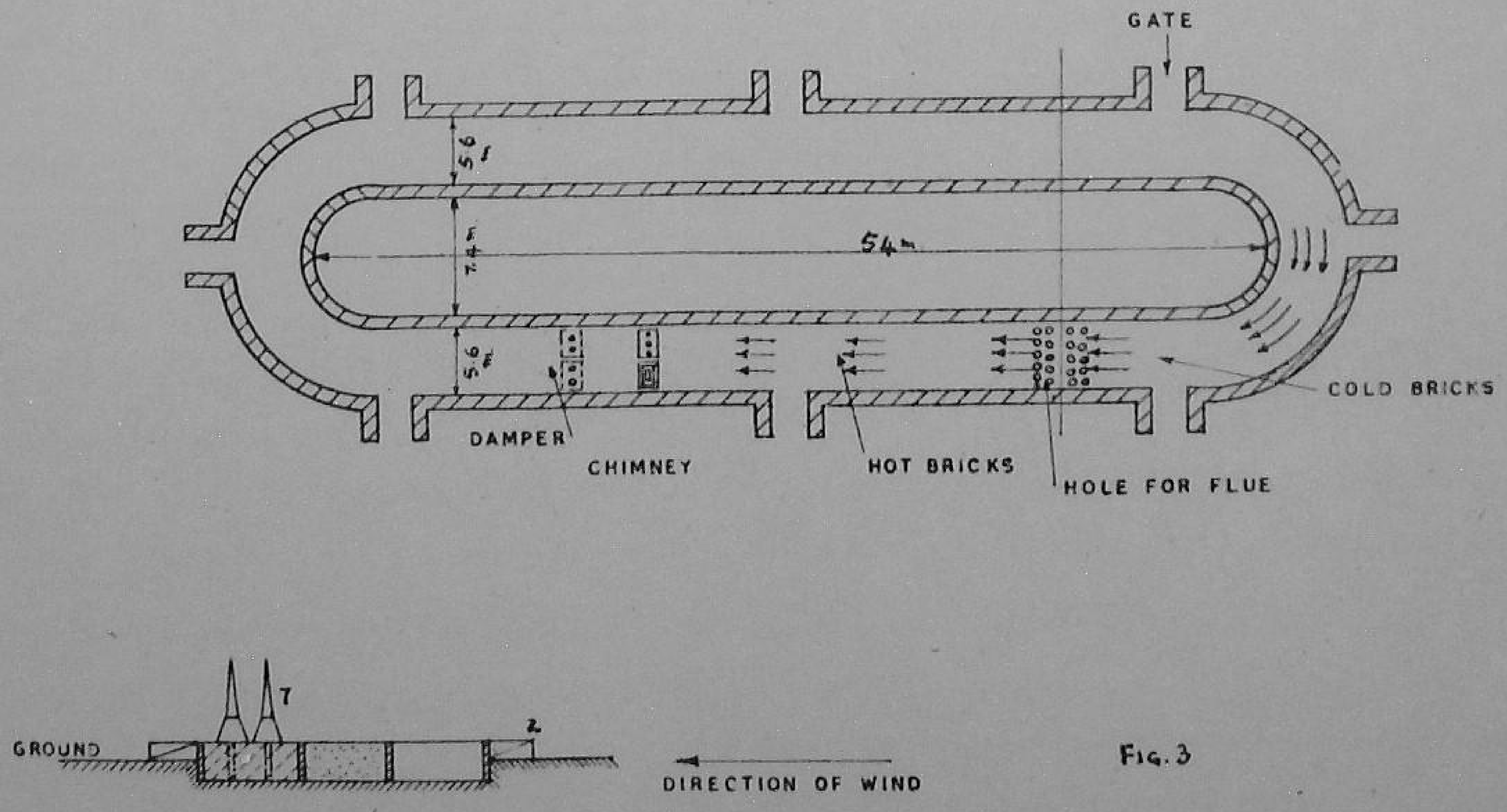


FIG. 3

STACKING TIMBER FOR AIR SEASONING

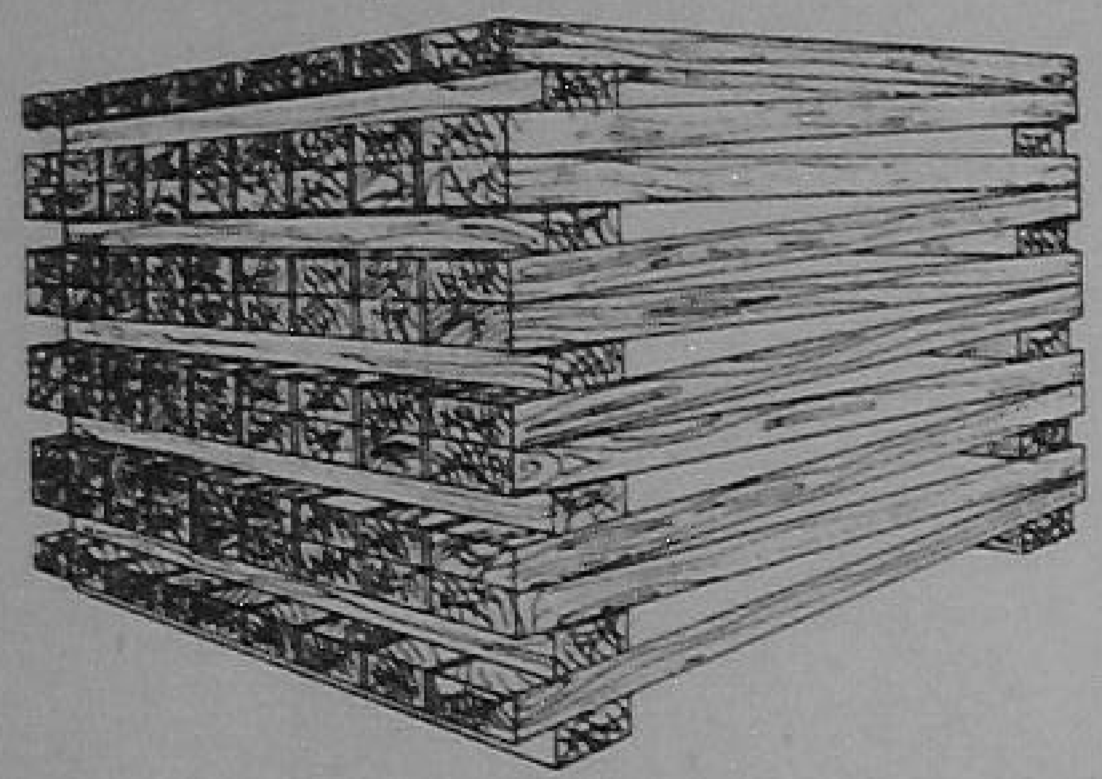


FIG. 4 ONE AND NINE STACKING

SL. NO.

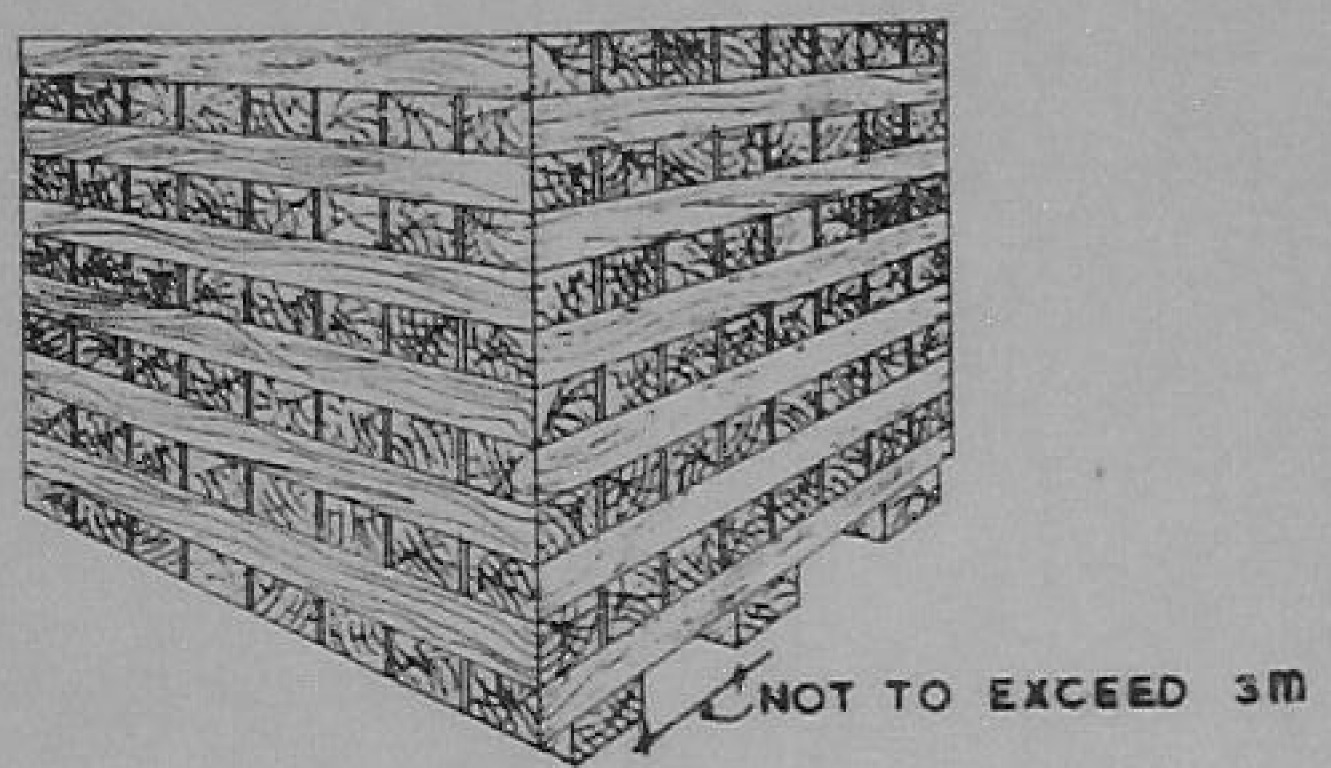


FIG. 5 CLOSE CRIB STACKING

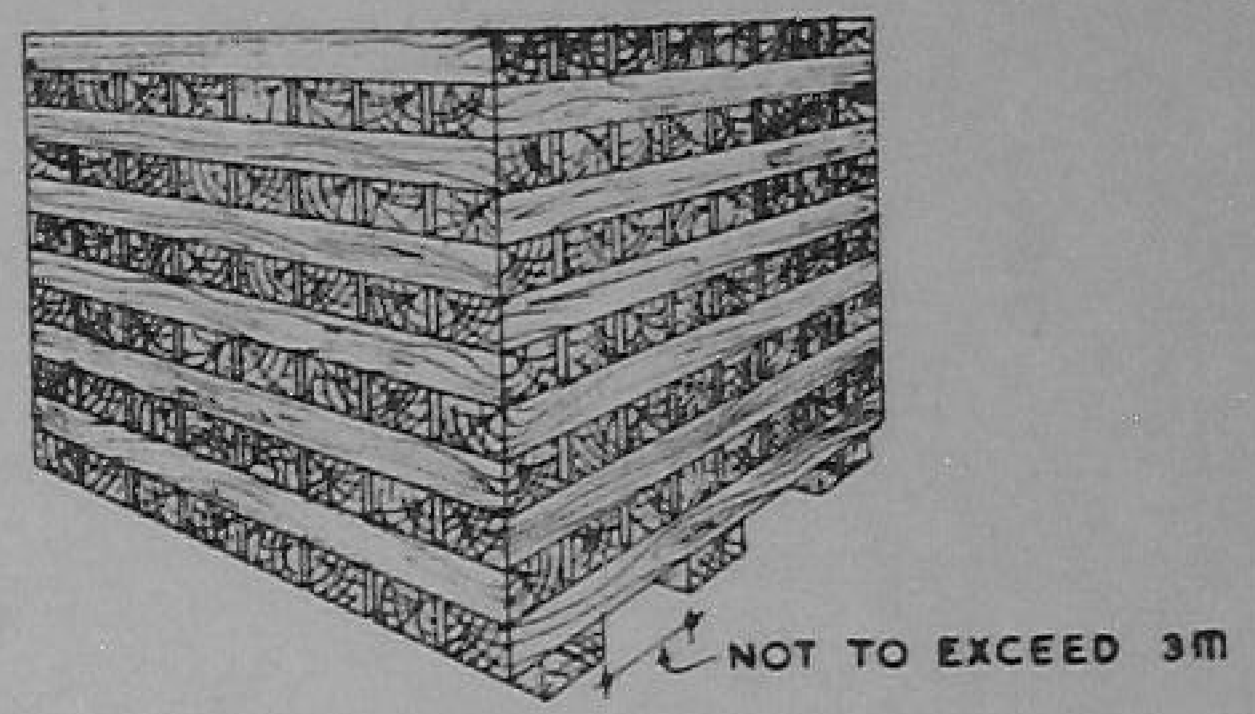


FIG. 6 OPEN CRIB STACKING.

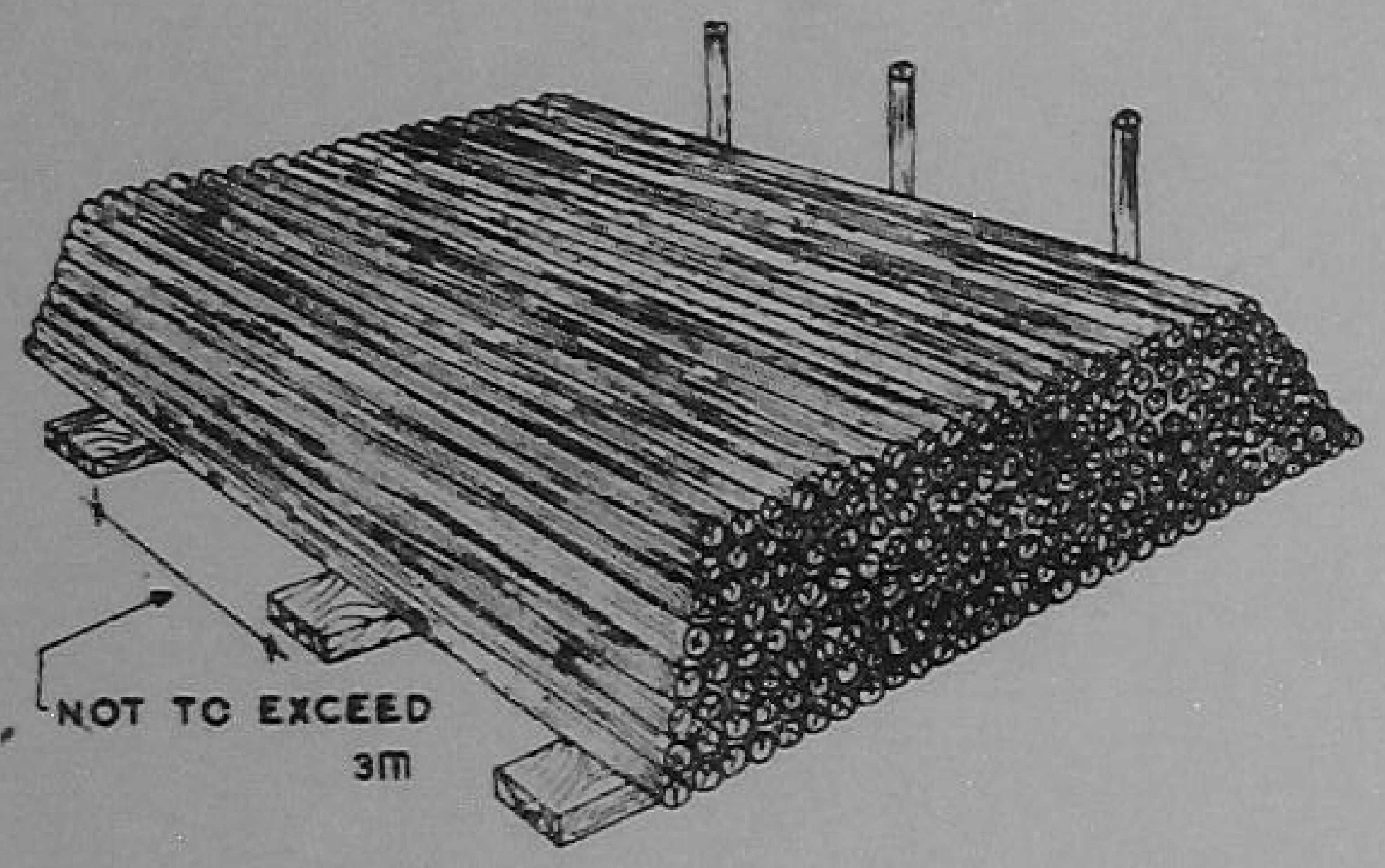


FIG. 7. STACK OF POLES

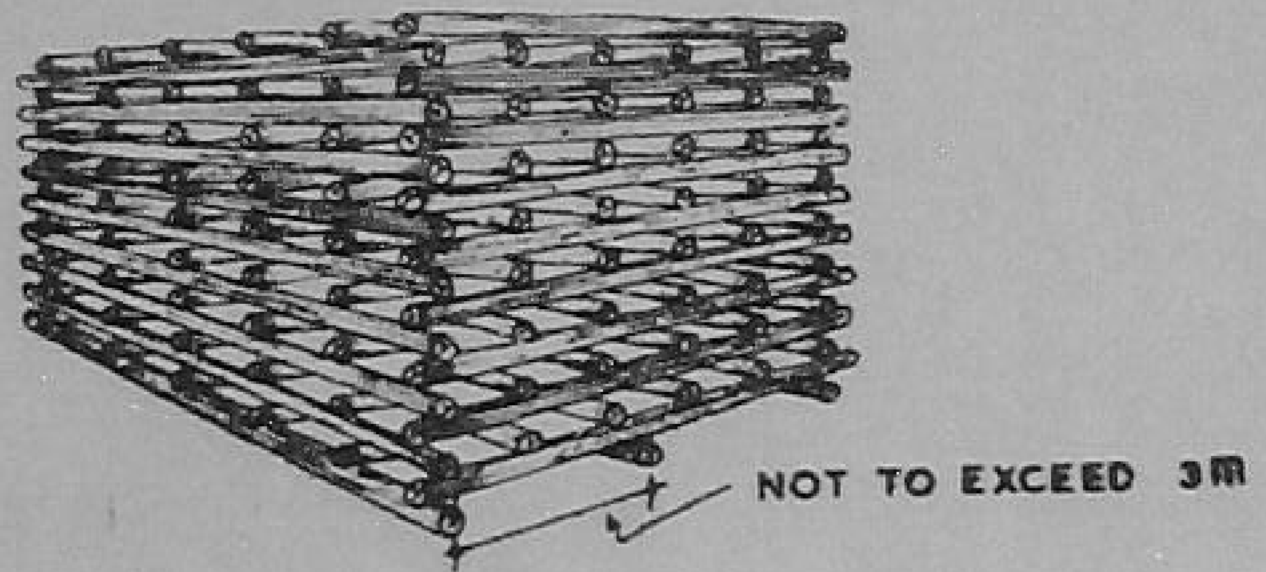


FIG. 8 STACK OF FENCE POSTS

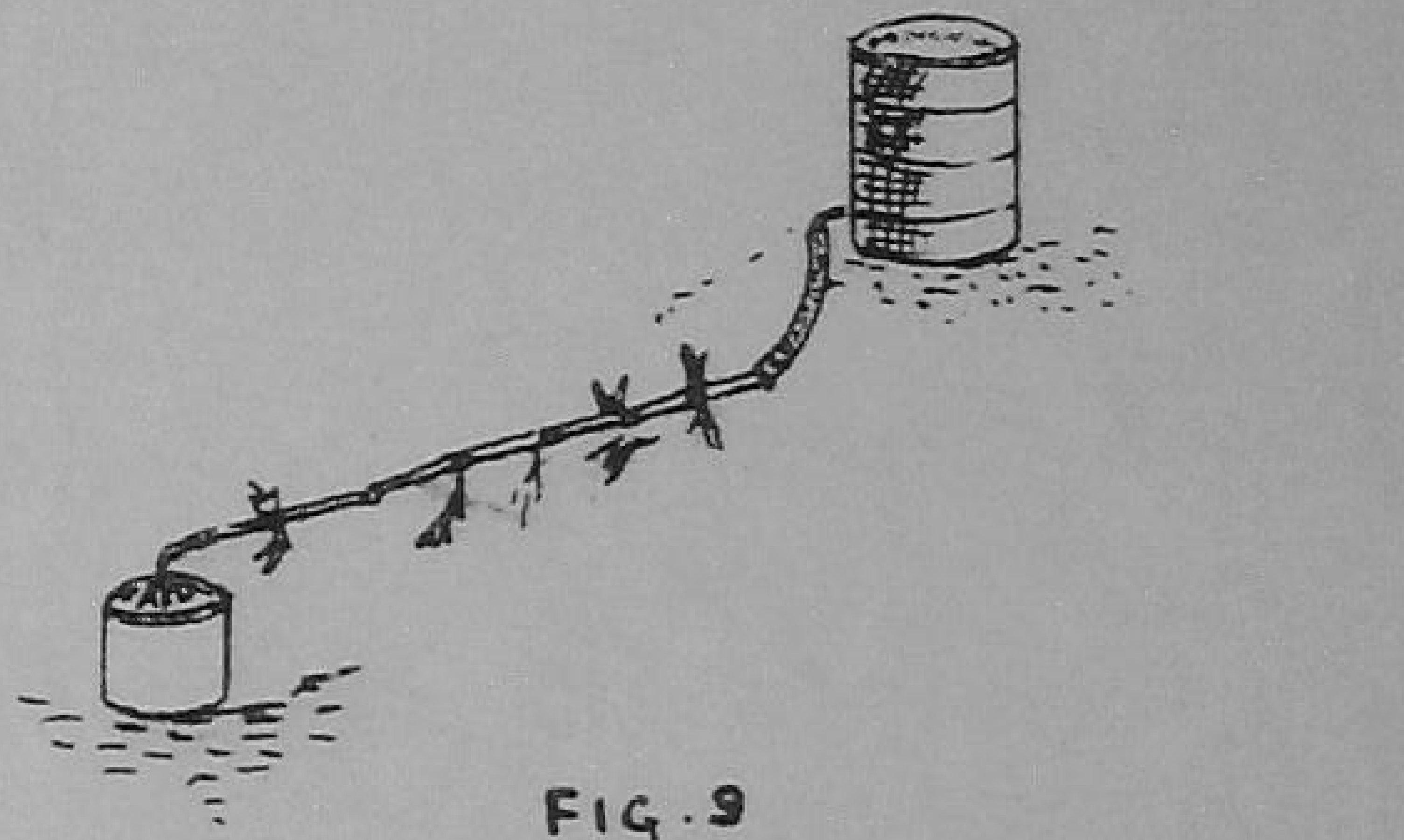


FIG. 9

9

Building Construction

9.1 Safe Bearing Capacity of Soils

9.1.1 Table 1 gives safe bearing capacity of various types of soils. These values can be used for the design of foundations.

TABLE 1

Sl. No.	Type of Rocks and Soils	Safe Bearing Capacity Tonnes/sq m	Remarks
	I—Rocks		
1	Rocks-hard without lamination and defects, *e.g.*, granite, trap and diorite.	330	
2	Laminated rocks (*e.g.* sand stone and lime stone) in sound condition.	165	
3	Residual deposits of shattered and broken bed rock and hard shale, cemented material.	90	
4	Soft rock.	45	
	II—Non-Cohesive Soils		
5	Gravel, sand and gravel, compact and offering high resistance to penetration when excavated by tools.	45	See Note 2.
6	Coarse sand, compact and dry.	45	Dry means that the ground water level is at depth not less than the width of foundation below the base of the foundation.
7	Medium sand, compact and dry.	25	
8	Fine sand, silt (dry lumps easily pulverized by the fingers).	15	
9	Loose gravel or sand gravel mixture; loose coarse to medium sand, dry..	25	See Note 2.
10	Fine sand, lose and dry.	10	
	III—Cohesive Soils.		
11	Soft shale, hard or stiff clay in deep bed, dry.	45	This group is susceptible to long term consolidation settlement.
12	Medium clay, readily indented with a thumb nail.	25	
13	Moist clay and sand clay mixture which can be indented with strong thumb pressure.	15	
14	Soft clay indented with moderate thumb pressure.	10	
15	Very soft clay which can be penetrated several inches with the thumb.	5	
16	Black cotton soil or other shrinkable or expansive clay in dry condition. (50 percent saturation).	10	
17	IV—Peat.	..	See Note 3; to be determined after investigation.
18	V—Fills or made-up-ground.	..	See Note 3; to be determined after investigation.

NOTE 1. Increase or decrease in allowable bearing values:

(a) The allowable bearing values may be increased by an amount equal to the weight of the material removed from above the bearing level, that is the base of the foundation.

(b) For non-cohesive soils the allowable bearing value shall be reduced by 50 percent if the water table is above or near the soil bearing surface. If the water table is below the soil bearing surface at a distance at least equal to the width of the foundation no such reduction shall apply.

NOTE 2. Compactness or looseness of non-cohesive materials may be determined by driving a wooden picket of dimensions 5×5×70 cm with a sharp point. The picket shall be pushed vertically into the soil by the full weight of a person weighing at least 70 kg. If the penetration of the picket exceeds 20 cm the loose state shall be assumed to exist.

NOTE 3. No generalized values for safe bearing pressures can be given for these types of soils. In such areas adequate site investigations shall be carried out and expert advice shall be sought.

(a) Peat may occur in a very soft spongy condition or may be quite firm and compact. While ultimate bearing capacity may be high in the compact cases, very large consolidation settlements occur even under small pressures and the movements continue for decades.

(b) *Made-up ground*—The strength of made-up ground depends on the nature of the material, its depth and age, and the methods used for consolidating it (if any).

9.2 Design of Foundations

9.2.1 *General*

(a) The foundations should be so proportioned that the pressure on the soil does not exceed the safe bearing capacity of the soil indicated under **9.1.**

(b) Foundations should be proportioned for the following combinations of loads:

(i) dead load+live load

(ii) dead load + live load + wind load.

(c) The factor of safety against overturning should not be less than 2.

(d) The factor of safety against sliding of structures which resist lateral forces (such as retaining walls) should not be less than 1·33 when dead load, live load and earth pressure are considered together with wind load, and 1·75 when dead load, live load and earth pressures only are considered.

9.2.2 *Depth of Foundations*

(a) All foundations should extend to a depth of atleast 80 cm below natural ground level. On rock or such other weather resisting natural ground, removal of the top soil may be all that is required. In such cases the bearing should be cleaned, and if necessary, stepped or otherwise prepared to prevent natural movement.

(b) Clayey soils like black cotton soils are seasonally affected by drying shrinkage and cracking in dry and hot weather and by swelling in the following wet weather to a depth which will vary according to the nature of the clay. It is necessary in these cases, to place the foundation bearing at such a depth that the effects of shrinkage are not important. In the case of predominantly clayey soils, it is recommended that the foundation be taken to a minimum depth of 90 cm.

9.2.3 *Spread Foundations*

(a) The angle of spread of the load from the wall base to the outer edge of the ground bearing should not exceed the following values:

In brick work and stone masonry	½ horizontal to 1 vertical.
In lime concrete	horizontal to 1 vertical.
In cement concrete	1 horizontal to 1 vertical.

(b) In the case of plain concrete footings resting on soil, the thickness should not be less than 15 cm.

(c) In the case of isolated columns, masonry footings should be permitted only where the subsoil is rocky.

9.2.4 *Foundation in Shrinkable Soils*

9.2.4.1 The peculiar property of the shrinkable soils is that they swell with absorption of large quantities of moisture and shrink when they dry up. This property is not restricted to the black cotton soil alone but to some other soils also which are not black in colour. Structures founded on shrinkable soils at shallow depths crack up due to seasonal variation in moisture content.

9.2.4.2 A number of tests carried out by various authorities have revealed that:—

(a) the foundations get affected more by the swelling of the soil than by its shrinking,

(b) swelling of soil in direct contact with the foundation material causes considerable damage to the structure,

(c) when structures are constructed during dry weather and sufficient intensities of pressure are transmitted to the foundations, the cracking is reduced,

(d) whether the roofs are made of R.C.C. prefabricated or cast *in-situ,* the binding at the roof level prevents cracks developing upwards and opening out,

(e) there is definitely a tendency for vertical cracks to develop between walls that transmit different pressures, such as between courtyard wall and the main building,

(f) there is hardly any variation in moisture content of soil at depths of 3·5 m and more. At a depth of 1·5 m even though there is variation in moisture content, there is only a small variation in the vertical levels.

9.2.4.3 In view of these observations, it is considered that:

(a) foundations in black cotton soils should be at least 1·5 m below ground level.

(b) the masonry below ground level should be clear of surrounding black cotton soil.

(c) for structures where shrinkage or swelling cannot be permitted, piles going down to depths of 3 to 3·5 m should be used.

(d) construction in shrinkable soil should be undertaken during dry season,

(e) dry joints should be provided between main building walls and courtyard walls and for walls more than 12 m long,

(f) where R.C.C. roofs are not used, a reinforced concrete binding course should be provided at the lintel level to arrest opening of cracks,

(g) It is better to use lime mortar stone masonry for construction. If stone is not available and bricks are to be used, at least lime mortar or composite mortar should be preferred to the inelastic cement mortar.

(h) By provision of suitable impervious pavements around the structure an attempt should be made not to cause any variation in moisture content of soil surrounding the foundations. (*See* Fig. 1).

9.2.4.4 The Central Building Research Institute, Roorkee has developed under-reamed pile foundations for shrinkable soils. These piles are bored with a special tool developed by the Institute.

NOTE.—The excavation should be carried out in the dry weather and the sand filling and the transmission of full load to be completed before the onset of wet weather.

9.3 Superstructure

9.3.1 *Mud Walls*—The stability as well as strength of mud walls can be improved by the following methods:

(a) *Foundations*—Proper compaction of soil in foundations at optimum moisture content will greatly add to its stability. The strength will be further improved in wet state if the soil could be mixed with cement at 2½ per cent by weight of soil.

(b) *Walls*—The irregular shape of the walls can be avoided by constructing the wall with sun-dried bricks or with machine pressed blocks.

(c) *Water Proofing*—The walls should be covered with water-proof mud plaster as described in Chapter 4.

(d) Ordinary mud walls are not recommended for regions where rainfall exceeds 1000 mm.

9.3.2 *Stabilized Soil Walls*—Generally stabilized soil construction is recommended in superstructure which is above the plinth level. The wall below the level of plinth is usually built with conventional materials like brickwork, lean concrete, etc. However, for this construction also stabilized soil with a richer proportion of cement may be used advantageously wherever such material is economical, provided the usual damp-proof course is inserted to prevent access to moisture, and also usual precautions are taken against termite attack.

According to IS: 2110-1962, the soil used for stabilized-soil construction should conform to the following requirements:

Sand content—not less than 35 per cent by weight.

Liquid limit—not more than 27 per cent.

Plasticity index—8·5 to 10;5 per cent.

Shuttering—Any timber found suitable in local practice may be used for shuttering. The planks should not be less than 20 cm in width and 5 cm in thickness. A typical arrangement of shuttering is shown in Fig. 2

After the shuttering is erected, the stabilized soil in moist condition should be poured into the shuttering in layers of 75 mm at a time. The layer should be uniform in depth. To control this depth, suitable templates may be used, which may be placed crosswise at intervals of about one metre.

Compaction should be done by workers standing inside the shuttering by means of iron rammers with about 8 cm × 8 cm base and of about 7 kg weight. Compaction should be started at the sides and worked inwards. Verticality of the shuttering should be checked periodically as compaction proceeds. For ramming soil at the edges of the forms, narrower rammers are useful, whereas heartshaped rammers are useful for indenting the surface of pise before a new layer is formed for creating a better bond between the layers.

The walls should be cured for 15 days after removal of the shuttering. Curing should be done by light sprinkling of water at short and regular intervals with a rose-can.

Vertical joints in the wall should be provided at a spacing not more than two metres apart. These should be done by means of a tongued and grooved dowel (*see* Fig. 3). The vertical joints should also be staggered. Horizontal joints should also be formed by finishing smooth rammed surfaces at the end of each lift.

Frames for doors and windows should be fixed in the wall by means of iron hold-fasts inserted in the wall before hand. For fixing hold-fasts in the wall, a circular hole of diameter sufficiently large to accommodate the hold-fast (generally 5 cm) and 30 cm deep should be bored with an auger in the constructed wall, and the forked end of the hold-fast should be inserted and the hole plugged with a rich mix of cement concrete. The frame should then be fixed to the hold-fasts by means of bolts.

Where a light roof frame work is resting on the wall, the portion of the wall directly below it should be built for a depth not less than 15 cm below the batten level, with either burnt clay bricks laid in cement mortar 1:6 or with soil having 7.5 per cent cement content.

Design of Walls—To compensate for the low structural strength of the material in earth walls, the walls are built dense and thick. The minimum thickness of exterior load-bearing walls of single-storey buildings are usually about one tenth of the height; interior non-bearing partition walls are made three-quarters of the thickness adopted for the exterior walls of similar height. Thus, for a normal single-storey cottage of traditional design, the minimum required thickness of the exterior walls will be 30 cm, and that of the interior partition walls 23 cm.

Walls must support loading due to dead and super-imposed loads and wind. They may sometimes have to support minor lateral loading due to persons, furniture, or ladders leaning against them. The slamming of doors and windows particularly doors slammed under wind pressure, exerts a considerable localized loading. The low strength of earth walls against lateral loading thus limits the minimum allowable sizes of piers between openings. It is recommended that for single-storey buildings having external walls of 30 cm thickness the minimum width between opening should be 90 cm; for walls of greater thickness this distance might be reduced by an amount equal to twice the additional thickness. Thus, for walls 45 cm thick the minimum distance between openings should be 60 cm.

9.3.3 *Rubble Masonry*—The Rubble masonry is divided into the following classes:

(1) *Coursed rubble first sort*—The height of the course should not be less than 15 cm. The stones in each course should be of equal height and all courses of same height. Joint thickness should not be more than 10 mm.

(2) *Coursed rubble second sort*—In this case the stones in each course should not all be of the same height, but not more than two stones, to be used in the height of the course. The joints may be as thick as 12 mm.

(3) *Coursed rubble, third sort*—In this course not more than three stones should be used in the height of the course. The joint thickness may be up to 16 mm.

(4) *Random rubble*—In random rubble masonry, the stones should be arranged to break joints as much as possible, and long vertical lines of joints should be carefully avoided in the face work.

9.3.4 *Bamboo Walling*—The use of bamboo for construction of walls, partitions and ceiling is as wide as it is varied. Either whole culms, halved culms, or longitudinally split bamboos are utilised for the construction of walls. These may be fixed either in a vertical or horizontal fashion depending on the local customs and fancies. A common form of wall construction practised in the different parts of India consists of fastening bamboo mats made from split bamboo to the posts or weaving the mats in between the posts and applying mud over the outside and inside surfaces. Sometimes, whole culms are driven into the ground in line with the main posts and fastened on both sides by longitudinal halves which are finally covered with mud. In better constructions cement plastering is also done on both the inside and outside surfaces on a layer of longitudinal halves of bamboos arranged in a vertical array. This kind of construction is very common in certain parts of Orissa, the bamboo generally used being *Bambusa mutans*.

Partition walls are generally of the lightest construction, being often single layers of bamboo matting fixed on a light frame work of bamboo poles. The width and the thickness of the strips and the mode of weaving the matting depends on the local practices. The same kind of matting is also used for the ceilings. As an alternative, a ceiling may consist of closely packed thin bamboo culms or lattice work of strips cut from bamboo culms. In some parts of Orissa half split bamboos are placed side by side with their convex surface downwards on a bamboo frame and mud is applied over it.

9.4 Doors and Windows

9.4.1 *Ledged Doors and Windows*—This type of doors and windows are also known as "country" doors and windows and are formed by fixing battens on to three ledges. The battens should be of uniform width not more than 225 mm and should have rebated joints. The thickness of the battens should be 25 mm and that of ledges 32 mm. The doors should be hung with battens outside and ledges inside.

9.4.2 *Battened and Braced Doors and Windows*—This type of door should be formed with battens 25 mm thick screwed to braces 32 mm thick. The size of the chowkhat may be 75 mm × 112 mm. The battens should have rebated joints, finished with a V on one side, and should be of uniform width, not more than 125 mm.

9.4.3 *Bamboo Doors & Windows*—Doors made of woven bamboo matting stretched and fixed on wooden or bamboo frames are very commonly used in rural houses in this country.

9.4.4 *R. C. C. Frames for Doors and Windows*—R. C. C. frames for doors and windows have become popular because of increasing scarcity of timber and its soaring cost. They are not only more durable but are economical in initial and recurring cost.

The Central Building Research Institute, Roorkee have developed an R.C.C. frame for doors and windows. The size is 90 mm × 63·5 mm The reinforcement consists of 3 bars of 6 mm diameter with stirrups of 3.15 mm diameter wire tied at 20 to 30 cm apart. One out of these three bars will project 50 mm beyond faces and 12 mm diameter holes will be left in the top horizontal members at the required place where the verticals join. In case of frames for windows, the bars should project 50 mm at both ends.

Two types of fixtures have been developed by C.B.R.I. for fixing shutters to chowkhat. The first type of fixture consists of an aluminium tube sleeve of 5 mm diameter having internal threading to suit 5 mm screws. The rear end is crimped flat to prevent ingress of concrete during casting. The second type of fixture consists of a helically wound wire of 0·9 mm diameter on a screw. The screw is held in a vice and the wire wound round it till it covers the screw and tails out by about 15 mm.

Mould for Vertical Member—A wooden mould 63·5 mm wide, 90 mm deep and 210 cm in length is made from sal wood. (See Fig. 4.) The base plate is 230 cm × 32 mm × 230 mm to which are fixed two vertical sides 230 cm × 90 mm × 25 mm at a clear spacing of 63·5 mm (inside). The two end pieces are fixed inside these vertical sides so that clear distance between the end pieces is 210 cm or the height of the door. The grooves are cut in the vertical sides and base plates to receive the end pieces. The vertical sides are held in position by a bolt at either end and three angle iron supports placed at the side of each vertical sides, one in the middle and one at about 15 cm from either end. The wooden wedges are inserted between the sides and the angle iron supports.

Rebate—To provide rebate, a wooden rebate piece 12·5 mm wide, 40 mm deep is fixed to the inside of one of the vertical members of the mould.

Hinges—Special arrangements have to be provided for fixing the hinges to R.C.C. chowkhats. Wooden pieces exactly equal in size, shape and thickness of the hinge to be fixed to the chowkhats are made (including holes for screws).

These pieces are fixed to the inside of the rebate pieces exactly at the true positions where the hinges, will be fitted. The holes are made in the rebate piece exactly at the position of holes made in the hinge pieces. The diameter of the holes made in the rebate piece is slightly greater than the diameter of the screw head to enable the screw head to come in contact with the hinge piece (*i.e.* to let the screw take exactly the same position which it will occupy when hinge is exactly fixed to the chowkhat). The wood of the vertical sides of the mould is removed at the back of the hinge pieces. An ordinary wire spring is embedded into the body of the chowkhat to receive the screws.

The spring is made by winding an ordinary binding wire on the threads of the screw. The screw is then taken out from this spring (by rotating the screw in the opposite direction). Now the screw is put from outside the mould in the hole provided in the hinge piece and spring is put on the screw from the inside of the mould. The screw head should come in contact with the hinge piece and spring should fit on the screw tightly.

In this position screw is in its true future position which it will take when the hinge is actually fitted to chowkhat. The screw is unscrewed and removed after 24 hours of the concreting of mould leaving the spring in position.

Casting—A 1:2:4 concrete mix is recommended with 10 mm aggregate. The members should be removed from the moulds after 24 hours. They should then be cured in water tank for a fortnight. Finally they should be removed to a covered place and stored for a month before use.

1:3 cement sand slurry should be filled in the holes at the junction of vertical and top members to obtain a satisfactory joint.

9.5 Flooring

9.5.1 *Brick on Edge Flooring*—The subgrade should be well rammed. Over this bricks on edge with fine joints should be laid. The joints should be grouted with sand. Flush cement pointing should be done over the joints. The pointing should be cured for a period of 7 days.

9.5.2 *Stabilized soil Flooring*

1. On the well rammed subgrade a 75 mm thick layer of well rammed stabilized soil is placed with 5 percent cement and 12 mm thick layer of 1·3 cement sand mortar on top.

2. On the well rammed subgrade a 50 mm thick layer of stabilized soil with $2\frac{1}{2}$ per cent cement and 33 per cent aggregate is placed. On top of this layer place a layer of cement concrete 20 mm thick.

9.5.3 Flooring in bath rooms and latrines should be 75 mm thick lime concrete (lime surkhi 1:2 with brick ballast) topped with 12 mm thick cement plaster.

9.6 Roofing

9.6.1 *Thatched Roofing*—Thatched roofing consist of bamboo framing over which layers of thatch are laid. The bamboo framing consists of vertical bamboos 40 mm in diameter laid 30 cm apart over which split bamboos are securely fastened at right angles 15 cm apart. The thickness of thatch, varies from 15 cm to 30 cm. The thatch is laid in layers 7.5 cm thick. The pitch of the roof is about 35 degrees generally. The operation of laying the thatch should begin from eaves upwards. The thicker (bottom) end of the 'poolas' (bundles of thatch) should be kept downwards.

'Poolas' should be placed touching each other with their length parallel to the sides of the roof and should then be opened and spread so that the thickness at the eaves is slightly more than 7.5 cm. It should then be roughly levelled. As each 'poola' is laid, the edge of the straw already in position should be slightly lifted up and the new straw should be pushed underneath about 25 mm or so, in order that adjacent poolas are lapped together and a compact and unbroken joint is made between the two. The straw should be gently beaten as it is laid and should be consolidated into a firm mass.

When the eaves row of poolas has been laid, a bamboo split into half should be laid on top at about 30 cm removed from the eaves parallel to it and tied down with tarred 'munj ban' pressing the straw under it.

The second and subsequent rows of poolas should be taken in hand in exactly the same manner, tying each poola to the supports and securing each row with split bamboo fillets. Each row of fillets should be placed at 30 cm intervals and should be concealed by the lower edge of poolas directly above.

'Munj ban' and strings used for tying should be dipped in coal tar and dried.

The process of laying should be repeated working upwards towards the ridge till the entire roof is covered, the surface being occasionally beaten gently, consolidated and combed down with hand rake to preserve a straight line from top to bottom and to keep each stem in its place. The completed thickness of this covering should be 7.5 cm.

Every effort should be made to ensure that the bundles of straw mingle together effectively at the edges as the life of the thatched roof depends very largely on the way the joints are made.

The verges of the roof should be laid with a double thickness of the straw to strengthen the edges. A split bamboo should be tied along the verges also.

The top of the roof should be finished off by laying bundles of straw longitudinally along the ridge, these being tied on as before, and being laid in just sufficient thickness to form a substantial (but not bulky) foundation for the crown of the thatch. The apex should then be covered in by placing the final row of poolas with their centre exactly across the top of the ridge and bending the ends down on either sides so that they can be tied to the bamboo foundation. The angle on the top should not be so acute as to buckle the straw.

The eaves and verges should then be trimmed up by cutting off the loose ends of the straw in a straight line with a long scythe.

9.6.2 *Doubly-Curved Pre-cast Plain Cement Concrete Tile Roofing*—This type of roof consists of doubly-curved pre-cast plain cement concrete tiles 68·5 cm × 68·5 cm in size, 20 mm thick with a central rise of 40 mm. The method of manufacture of these tiles has been explained in Chapter 8. The tiles are laid with 25 mm bearing on partially pre-cast beams 125 mm wide and 90 mm deep, placed 75 cm centre to centre. Concrete is laid *in-situ* on the top along the length of the beam to form the compression flange of the beam.

The beams are designed as T beams partly pre-cast and partly cast *in-situ*. To ensure bond between the two stirrups are left projected 25 mm above the pre-cast ribs which are 125 mm wide and 90 mm deep. The top surface of the pre-cast rib should also be finished rough for this purpose.

Method of Placing Beams & Tiles—The beams are laid to a slope of 1 in 40 and are placed 75 cm centre to centre. The clear distance being 62·5 cm between the beams. Out of the 125 mm width of the beam 25 mm on either side is covered by the tiles, leaving 75 mm clear space to give bond to upper part of the beam.

The beams should be propped at one-third points before the tiles are placed over them. After the tiles have been laid to correct fit a coat of neat cement slurry is applied to the joints of the adjacent tiles and cement concrete 1:2:4 is filled full in the haunches along the beams and up to a depth of 15 mm only across the beams, *i.e.* the joints perpendicular to the beams.

Concrete in roof terracing is laid as usual for thermal insulation and resistance to rain penetration. The thickness of lime concrete may be 75 mm throughout as the slope of 1 in 40 has already been given in the beams.

The props should be removed after water-proofing treatment is completed.

9.6.3 *Second Class Mud Roofing*—Second class mud roofing consists of one layer of 30 cm × 15 cm × 5 cm brick tiles laid in cement sand mortar 1:4 over wooden or R.C.C. battens. The top surface of the tiles is covered with 6·5 mm thick cement sand plaster 1·4 (1 cement: 4 sand) and the bottom surface of the tiles is flush pointed with cement mortar 1:3.

The tiles should be painted with two coats of hot bitumen at the rate of 2·4 kg/sq m and should be covered with 75 mm thick mud and 25 mm thick mud plaster finished with gobri leeping.

The battens should have properly finished surface at the top so as to give an even bearing to the tiles. The necessary main slope in the roof should be formed by sloping the beams or battens.

Tiles resting on walls should have a bearing of at least 120 mm and in no case less than 75 mm, and should abut closely against the brickwork in the parapet, leaving no void; wherever possible, the end of the tile should be bonded into the brick work.

9.6.4 *First Class Mud Roofing*—First class mud roofing comprises of two layers of 30 cm × 15 cm × 3·2 cm brick tiles carried over wooden or R. C. C. battens. The joints in the two layers of tiles are staggered. Other details are similar to second class mud-roofing.

9.6.5 *Reinforced Concrete Slab Roofs*—These roofs can be designed from the tables given in Chapter 10.

9.6.6 *Reinforced Brick Work Roofs*—These roofs can be designed from the data given in Chapter 10.

9.6.7 *Jack-Arch Roofing*—The jack-arch roofing is a type of composite construction consisting of a row of brick arches of small rise and over it a lime concrete layer. In addition to the strength of the arches, the jack-arch roof derives its strength from the lime concrete layer by virtue of the latter's bond development with bricks.

Jack arches are constructed of bricks laid on edge in a single course with cement mortar 1:3 and supported over steel or concrete I-shaped joists spaced at centres of one to two metres. The usual spacing of joists varies from 1 to 1·5 metres. The joists should be designed as beams supporting the portion of terrace coming over them.

The jack-arch should be built in the form of segment of a circle with a rise of about 1/8 of the span. Tie rods at designed spacings are provided in the outer arches. Tie rods should not be less than 12 mm in diameter.

The thrust of the arch which is to be resisted by the tie rods may be found as follows:

$$T = \frac{12.5\ WL^2}{R}$$

where

T = thrust of arch in kg per running metre.

W = live and dead load on the arch in kg/sq m on end span and live load only for intermediate spans,

L = Span of arch in metres, and

R = Rise in cm.

The tie rods should be placed generally not less than 7·5 cm above the bottom of the joists and their spacing should not exceed 20 times the width of the joist. These rods should be properly anchored with stout mild steel washers or angle irons. For anchoring tie rods into the end wall, a separate encased beam may be used in case the thickness of the wall is not sufficient to afford full anchorage by other means.

In a series of jack-arch spans tie rods should be provided in the end spans. For the interior spans, the thrust of the arch will generally be taken up safely by the arches in the adjacent spans, but any local concentrations of load should be suitably taken care of in the design, and tie rods should be provided, if necessary.

When end spans are shorter than the central spans, the tie rods should be provided for at least two or more spans near the end, so that the end spans provide a rigid lateral support capable of taking the horizontal thrust from the central spans even under the most unfavourable loading conditions.

After the brick arch has set, a layer of lime brick ballast concrete of mix 1:2.5 (slaked lime: brick ballast by volume) should be laid and spread so as to have an initial thickness of 75 mm over the crown of the arch. The lime concrete should then be consolidated with wooden rammers of weight not exceeding 2 kg so that its consolidated thickness over the crown is 60 mm. The concrete should further be beaten with wooden hand beaters till the beater makes no impression and readily rebounds from the surface when struck on it.

9.6.8 *Precast Curved Hollow Guna Tile Roofing*—The C.B.R.I. Roorkee have developed this type of roofing units suitable for spans up to 4·25 metres. The unit is 110 cm long, cm wide and 7:5 cm deep. Each unit weighs about 40 kg and can be easily handled by two persons. It is cast on a curved masonry platform. Two rows of guna tiles are arranged in the form of an arc of a circle or a parabola. Concrete 1:2:4 mix (with 10 mm aggregate) is then poured to a thickness of 13 mm. After 24 hours or so the units are removed and cured. The supporting beams for these units are trapezoidal, 150 mm wide at the bottom, 75 mm wide at top and 130 mm deep. The beam reinforcement consists of 2 to 3 bars of 12 mm diameter (depending upon the span) with 6 mm diameter stirrups projecting to provide bond with *in-situ* concrete. The beams are designed as T-beams and laid at 1·2 metres centre to centre. The end beams are anchored to the supports and units are laid in between to the correct fit. The haunches are then filled in with cement concrete 1:2:4 up to the depth of the flange. Concrete is then cured and the protective treatment is laid as required.

9.6.9 *Stone Slab Roofing*—This type of roofing is very common in those areas, where stone slabs are available in plenty. The width of slabs should, normally, be not less than 40 cm. The maximum spacing of rafters of R.C.C. battens supporting the slab should not exceed the following figures for various slab thickness.

Thickness of Stone Slab	*Maximum Centre to Centre Spacing of Rafters*
40 mm	50 cm
45 mm	60 cm
50 mm	70 cm

The bearing of slabs over rafters should not be less than 35 mm. The thickness of joints should vary between 5 and 8 mm. The slabs should be jointed with cement mortar 1:4 and flush pointed with the same mortar.

9.6.10 *Mud Roof Carried Over Bamboos, Ballies, etc*—This type of roof is commonly met with in village houses in the plains of Northern India. It comprises of about 150 mm thick mud finished with mud plaster and gobri leaping carried over bamboos and ballies. Depending on the size of the bamboos, the ballies are placed at 30 to 40 cm centres. The bamboos are placed almost side by side. It is quite a common practice to provide palm leaf matting above the bamboos before laying the mud. The matting is sometimes omitted and in this case, straw is added in the mud before laying it directly on the bamboos.

This type of flat roof is very cheap and provides good thermal insulation. Its performance can be greatly improved if in the top layer of mud plaster 3 per cent tar by weight of soil is added.

9.6.11 *Roof Slopes*—The following roof slopes are generally adopted:

(a) Mangalore tiles screwed down—1 in 1 or steeper.

(b) Mangalore tiles not screwed down—1 in 2 to 1 in 1.

(c) Allahabad or country tiles—1 in 2.

(d) Corrugated G.I. Sheet and A.C. Sheets—1 in 4.

9.6.12 *Corrugated G.I. Sheet Roofing*—The purlins should not be spaced more than the following centre distances for the various thicknesses of C.G.I. sheets.

1·00 mm	2·0 metres
0·80 mm	1·8 metres
0·63 mm	1·6 metres

The sheets should be laid with a minimum lap of 15 cm at the ends and 2 corrugations at each side. The above minimum end lap of 15 cm should apply to slopes of 1 vertical to 2½ horizontal and steeper slopes. For flatter slopes the minimum permissible lap should be 23 cm.

Sheets should be fixed to purlins or other roof members, such as hip or valley rafters, etc with galvanised 'J' or 'L' hook-bolts and nuts, 8 mm diameter, with bitumen and limpet washers or with limpet washers filled with white lead. The bolts should be sufficiently long so that after fixing they project above the top of their nuts at least 12 mm. The grip of 'J' or 'L' hook bolt on the side of the purlin should not be less than 25 mm. There should be a minimum of three hook bolts placed at the ridges of corrugations in each sheet on every purlin and their spacing should not exceed 30 cm.

9.6.13 *Asbestos Cement Corrugated Sheet Roofing*—The maximum spacing of purlins under the sheets should be 1·6 m for 7 mm thick sheets and 1·3 m for 6 mm thick sheets. The sheets should be laid with the smooth side upwards and with a side lap of half a corrugation and an end lap of 15 cm minimum. The sheets should be fixed with 'J' or 'L' hook bolts similar to G I. Sheets.

9.7 Damp-Proof Course

9.7.1 Penetration of dampness into the building is a big nuisance to the occupants. Dampness, besides creating unhygienic conditions, is also responsible to a large extent for the loss in durability of a structure. Also the process of intermittent wetting and drying causes expansion and contraction of the building resulting in loss of adhesion of the plaster and appearance of cracks. Warping and rotting of the wood and wooden products and corrosion of metals can also often be traced to the presence of dampness. In addition, it is conducive to the growth of termites. It is, therefore, very essential that amount of dampness in the building should be controlled as far as possible, if not completely eliminated. Damp proof course is provided to prevent the rise of ground moisture in the walls.

9.7.2 In buildings, the damp-proof course consists of a layer of cement mortar or cement concrete 25 mm to 40 mm thick painted over with two coats of bitumen—the first coat @1·2 kg/sq m and the second coat @0·7 kg/sq m covered with coarse sand @0·006 cu m per sq m.

9.7.3 If burnt clay bricks are soaked in 2 per cent soap solution for about 15 to 20 minutes and then dried, they become very much impervious and can be used as damp proof course in buildings as an alternative to the conventional damp proof course. Two layers of soap treated bricks as a damp proof course have yielded very satisfactory results in checking the rise of ground water and salts and thus preventing the appearance of efflorescence. The brick should be laid with cement sand mortar containing 1 per cent soap solution.

9.7.4 In buildings made with sun-dried bricks damp-proof course can be provided by laying two courses of burnt bricks dipped in tar. The bricks should be laid in coal tar sand mortar, consisting of 15 kg of tar in 100 kg of sand.

9.8 Termite Proofing

9.8.1 Termites are of two types; the ground inhabiting or subterranean termites and dry wood termites. Dry wood termites are not as prevalent and common as subterranean termites, and are generally confined to coastal regions.

9.8.2 Subterranean termites are responsible for most of the termite damage to buildings in India. They live underground where they find the unfailing source of moisture without which they would die. They build tunnels through earth, and covered runways around unpalatable material above ground to get at the wood or other cellulosic material they need for food. These runways provide them protection and access to ground moisture.

Subterranean termites establish themselves in buildings which they enter through cracks or hollows in masonry walls, joints in floor blocks, tunnels excavated in lime mortar, fine cracks or fissures in concrete and through runways built over the surface of foundations, walls, pipes, conduits, etc.

The eradication of termites from buildings in which they have established themselves is extremely difficult if not impossible without extensive and costly structural alterations and hence protection against them should be provided during construction. It is estimated that termite proofing treatments cost no more than one to two per cent of the total cost of building. The different steps that may be taken to make a building termite proof are briefly described below.

9.8.3 *Preparation of Buildings Site*

(a) *Site clearance*—The breeding of termites in the locality where a building is to be constructed should be discouraged by removing stumps, roots, waste wood and plant debris. Special care should be taken to remove wooden shuttering completely.

(b) *Mound treatment*—If termite mounds are discovered in the area, they should be destroyed by the use of insecticides. Contrary to popular belief, a colony of termites cannot be destroyed by removing or killing the 'queen' since they possess the faculty of replacing the queen by another.

Insecticides should be poured into the mounds at several places after breaking open the earthen structure. The quantity to be used will depend on the size of the mound. For a mound volume of about 0·6 cu m, one of the following may be used:

(1) 1·2 kg of 10 per cent dust of D.D.T.
(2) 4·5 litres of 2 to 3 per cent solution in water of sodium arsenite;
(3) 18 litres of 0·5 to 1 per cent suspension in water of gamma benzenehexachloride;
(4) 2·5 litres of 0·004 per cent emulsion of aldrin in water.

(c) *Soil treatment*—Treating the soil beneath the building and in the vicinity of both sides of the foundations will be helpful in localities where termites are plentiful.

A narrow trench about 30 cm wide is dug adjacent to and around the foundation walls and piers to a depth of about 45 cm and the soil poison is poured in. Additional amounts are poured in from time to time as the trench is being filled. A dosage of 15 litres of one of the following per linear metre of trench is recommended:

(1) A mixture of 1 part of creosote to 2-3 parts of kerosene.
(2) 10 per cent solution of sodium arsenite in water.
(3) 5 per cent solution of pentachlorophenol in fuel oil.
(4) 5 per cent solution of D.D.T. in kerosene. The newer insecticides—aldrin, dieldrin and chlordane—may be used at the rate of 6 litres of 0·5 per cent emulsion per linear metre. The area under the building should also be treated. A dosage of 5 litres per square metre is recommended. The best method of treatment is to spray the poison over the consolidated filling beneath the floor. After treatment care should be taken not to rupture the protective layer of poisoned soil.

9.8.4 *Structural Obstacles*

(a) *General principles*—The best protection against termites is to adopt materials and methods of construction which will prevent their gaining access to the building. An

impenetrable physical barrier placed between ground and the superstructure of the building will prevent their entry through the foundations and walls. Further, termites can cross the surface of the barrier only under cover of an easily-seen earthen runway. Buildings should, therefore, be so constructed that these surfaces are easily accessible for inspection and treatment.

(b) *Foundations*—The foundations should be of dense concrete or other solid material through which termites cannot penetrate. With brick, stone, etc, cement mortar should be used because termites can work through weaker mortars. Lime mortar is unsuitable but cement mortar having not more than 15 per cent by volume of hydrated lime may be used.

Concrete in which the mixing water is replaced by a 0.5 per cent emulsion of dieldrin will prevent termite entry. This idea is now being used in Australia, in addition to normal soil treatment, to prevent termites from entering buildings through concrete in foundations and flooring. The addition of 0.5 per cent dieldrin does not affect the strength of the concrete.

(c) *Termite barriers*—Termite barriers are of two kinds:

(1) Concrete barrier over plinth walls to force the termites out into the open, and

(2) metal shields to prevent the entry of termites through and over the surface of the walls.

A continuous concrete slab about 75 mm thick cast over the plinth walls and projecting 50 to 75 mm internally and externally, will prevent penetration by termites up through the walls. The concrete should be dense and free from cracks. The barrier will not stop the building of runways over the projection and up the surface of the walls, but they will be exposed and can be seen and destroyed. Regular inspection is essential.

Metal termite shields are used to supplement good constructional methods of termite proofing. They consist of sheets of corrosion resistant metal, such as copper, zinc, galvanised iron, or aluminium placed over the foundation walls and piers. They should extend 50 mm beyond the face of the wall and then bend down at an angle of 45° for about another 50 mm. Termites are seldom able to negotiate the edge of the shield. (See Fig. 5).

Minimum thickness of metal should be about 0.45 mm. It should be continuous with all joints soldered or tightly crimped. All pipes, conduits or other facilities entering the building should also be provided with tight fitting collars similar to the shields. In order to be sure that the barriers remain intact and maintain continuity of protection, regular inspection is necessary. If the bearers of the building are bolted to the pillar, care must be taken to seal the gap between the edge of the hole through the metal cap and the bolt by coating top of the pillar with a layer of bitumen before placing the cap in position.

(d) *Bridging*—Care must be taken to see that a bridge is not formed by special parts of the building above the termite barrier. Steps should be effectively separated from the building or should start from a protected plinth.

(e) *Floors*—Brick floors are seldom proof against termites. If a concrete floor is used, joints between floor slab and wall should be such that penetration by termites will be immediately noticed. If a concrete barrier is laid over the foundation walls, it should extend 50 to 75 mm internally and the concrete floor should be butted on to this course and the junction and all other expansion joints filled with suitable anti-termite preservative or with coal tar pitch. Alternatively the concrete floor may simply be carried over the foundation walls and projected externally.

9.8.5 *Superstructure*

Whenever possible, wood, boards and other susceptible material used in building should be treated with preservatives. Untreated wood or wood not naturally resistant to termites should not be placed in contact with or close to the soil. Wooden door frames, staircases etc., should be set on flooring but not through flooring.

9.9 Water-proofing of Roofs

9.9.1 *Lime Concrete Water-Proofing*—Lime concrete of the following mix should be laid in a single layer 7.5 to 12 cm thick:

(a) 2 lime : 2 surkhi: 7 brick ballast 25 mm gauge (Bombay and Calcutta region).

(b) 1 lime : 2½ brick ballast 20 mm gauge (Madras region).

(c) 25 mm gauge brick ballast with 50 per cent lime mortar consisting of 1 lime : 2 surkhi (Delhi, U.P., Punjab and Rajasthan regions).

The concrete should be lightly rammed with 5.5 kg rammers to the required thickness, slope and levels. The concrete should be used when it is quite fresh; concrete left over from the previous day's work should in no circumstances be used.

During this preliminary ramming, the surface should be tested and kept perfectly true and even, by means of a trowel, straight edge and spirit level. The concrete should then be further consolidated by two rows of labourers sitting close and beating the concrete in unison with wooden 'thapis' across the entire width of the roof and thus slowly traversing the length of the roof. Special care should be taken to properly consolidate concrete at its junction with the parapet walls. This beating should be continued for three to four days or until the mortar is almost set and the wooden 'thapis' rebound from the surface readily, when struck on it.

While the beating is in progress, the surface should be liberally sprinkled with a mixture of 'gur' and boiled solution of Bael fruit, in the proportion of 2.8 kg gur to 1.6 kg Bael fruit to 100 litres of water.

As soon as the beating is completed, the mortar that has come on top should be softened by the addition of the solution of gur and Bael and smoothened with a float or trowel to a fine polish.

No plaster should be used on any account for finishing the roof.

As soon as the surface has been brought to a fine polish, it should be kept damp for a minimum period of 10 days by spreading straw, and watering at frequent intervals from a watering can through a perforated rose, in moderate quantity so as to ensure thorough setting of the concrete.

9.9.2 *Mud Phuska Topped with Tile Bricks*

Mud mortar—Mud mortar should be prepared from good brick earth. This should be free from grass, roots, gravel, kankar, etc. The earth should contain no efflorescent salts, nor should it be collected from a locality where there are white ants. The earth should be reduced to a fine powdered state and mixed with plenty of water in a pit adding 'bhusa' at the rate of 8 kg per cu m of puddled clay. The mixture of earth, straw and water should be allowed to mature for not less than 4 days. During this period it should be worked up at intervals with feet and/ or 'phowras 'so that it gets pugged into a homogeneous mass free from lumps and clods.

Laying—The mortar should be laid on the terrace to requisite thickness and slopes in a single layer and rammed with wooden 'thapis' under optimum moisture condition. The surface should be checked with the same mortar, where necessary and allowed to dry. If any cracks appear, these should be filled with liquid cowdung. The slope of the finished surface should not be less than 1 in 50. The surface should slope from all sides towards the outlets. The thickness of the consolidated mud phuska at any point should not be less than 5 cm. The

average thickness of the finished mud phuska over the entire area should be about 10 cm or as required at site depending on the required slope.

Mud gobri plaster—The surface should then be given a coat of plaster with mud gobri mortar 3:1 (3 mud: 1 cow dung). Cow dung is soaked in water to free it from grass, straw, seeds and other impurities. It should then be sieved if necessary. Fine earth should be added to this solution in the ratio of 3 parts by volume of fine earth to one of cow dung. The two shall be thoroughly incorporated by mixing and adding sufficient water so that the mortar is in a workable state. The thickness of the plaster should be 13 mm uniform throughout. The surface should be checked for slopes, etc, and corrected as necessary.

Topping with tile bricks—The surface should be cleaned and watered. 13 mm cement mortar (1 cement: 3 fine sand) mixed with 5 per cent crude oil based on the weight of the cement should be spread on the surface evenly and to required slope. Tile bricks 13 to 20 mm thick which have been soaked in water for at least four hours beforehand shall then be laid in cement mortar 1:3 (1 cement: 3 fine sand) with 5 per cent of crude oil based on the weight of the cement. The tiles should be laid with their longitudinal lines of joints parallel and horizontal and at right angles to the sloping edges of the roof. Transverse joints in alternate courses should come in a straight line and in adjacent courses should not break joints by less than 5·7 cm. The joints should be pointed with the same cement mortar and finally rubbed with thin iron bars until the surface gets hard and polished.

Curing—The tile brick work should be cured for at least seven days and during this period it should be suitably protected from damage.

9.9.3 *Lime Concrete Terracing with Flat Tiles*—After laying lime concrete terracing it should be topped with two courses of flat tiles 13 mm thick, breaking joints. The tiles should be set in cement mortar 1:3 mixed with 5 per cent of crude oil, based on the weight of cement. The joints should be pointed with the same cement mortar and finally rubbed with thin iron bars until the pointed surface gets a polish and becomes hard. This specification is very much in vogue in the Madras region.

9.10 Skeleton House

9.10.1 For solving rural housing problems a skeleton or framed house offers many promising opportunities. In areas where stone is available in plenty, the house frame can be constructed of stone columns and beams. The filler walls can be made of sun dried bricks to start with. These walls can be replaced by pucca walls one by one as and when money becomes available. The National Buildings Organisation is also working on the development of precast prestressed portal frame for rural houses. This frame may be useful in rural areas in the vicinity of a prestressed concrete factory.

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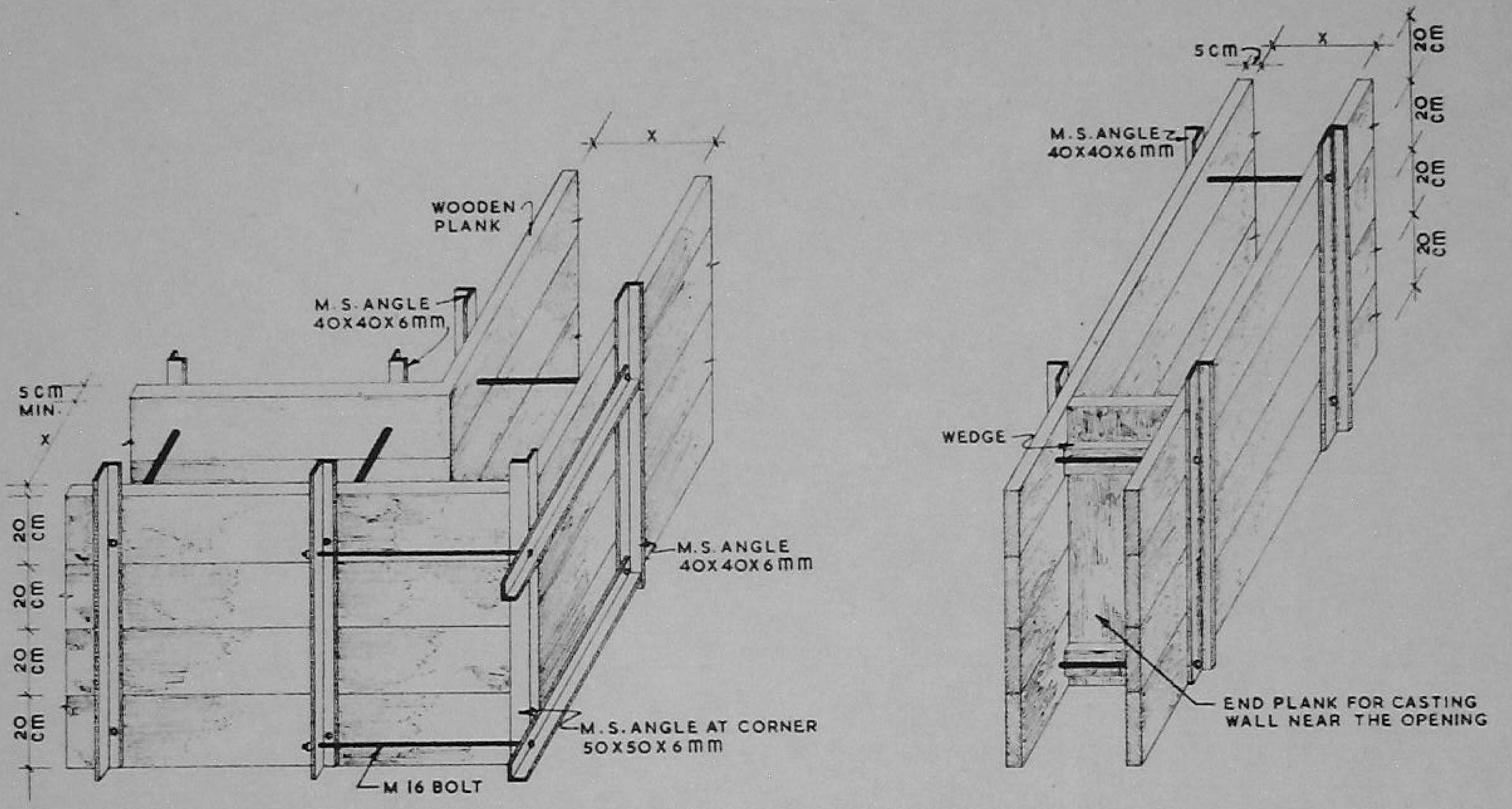
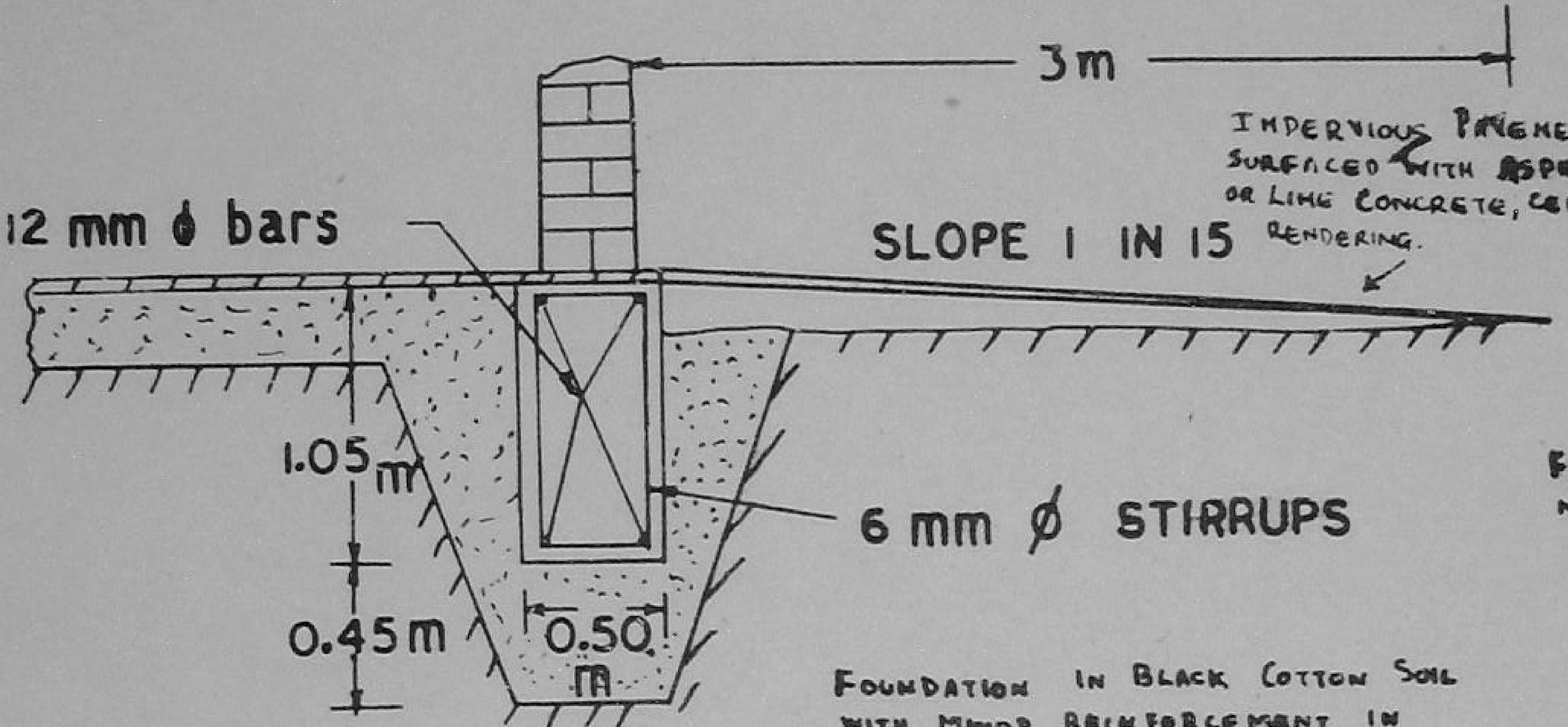
FIG.2



NOTE: THE THICKNESS OF WALL (CORRESPONDING TO DIMENSION X) GENERALLY USED IS 30 cm. IF THE THICKNESS OF WALL IS OTHER THAN 30 cm, THE SHUTTERING DETAILS WILL HAVE TO BE SUITABLY MODIFIED.

DETAILS OF WALL SHUTTERING FOR STABILIZED EARTH CONSTRUCTION



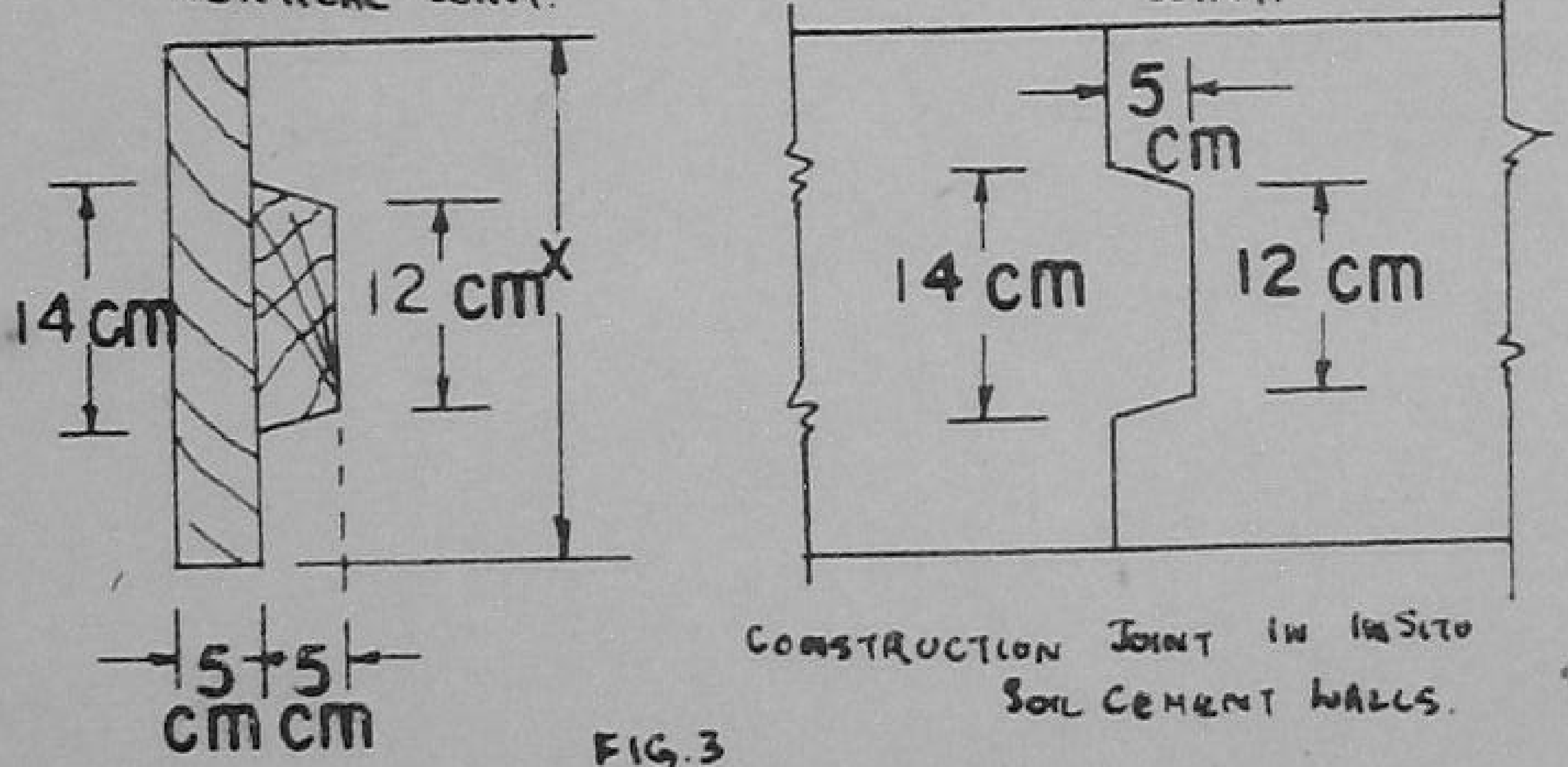
FOUNDATION IN BLACK COTTON SOIL WITH MINOR REINFORCEMENT IN FOOTING AND WITH SAND FILLING.

FIG. 1

FIG 2 ON NEXT PAGE

3a. SECTION OF PLANK USED FOR MAKING VERTICAL JOINT.

3b. PLAN OF VERTICAL TONGUE AND GROOVE JOINT.



CONSTRUCTION JOINT IN IN-SITU SOIL CEMENT WALLS.

FIG. 3

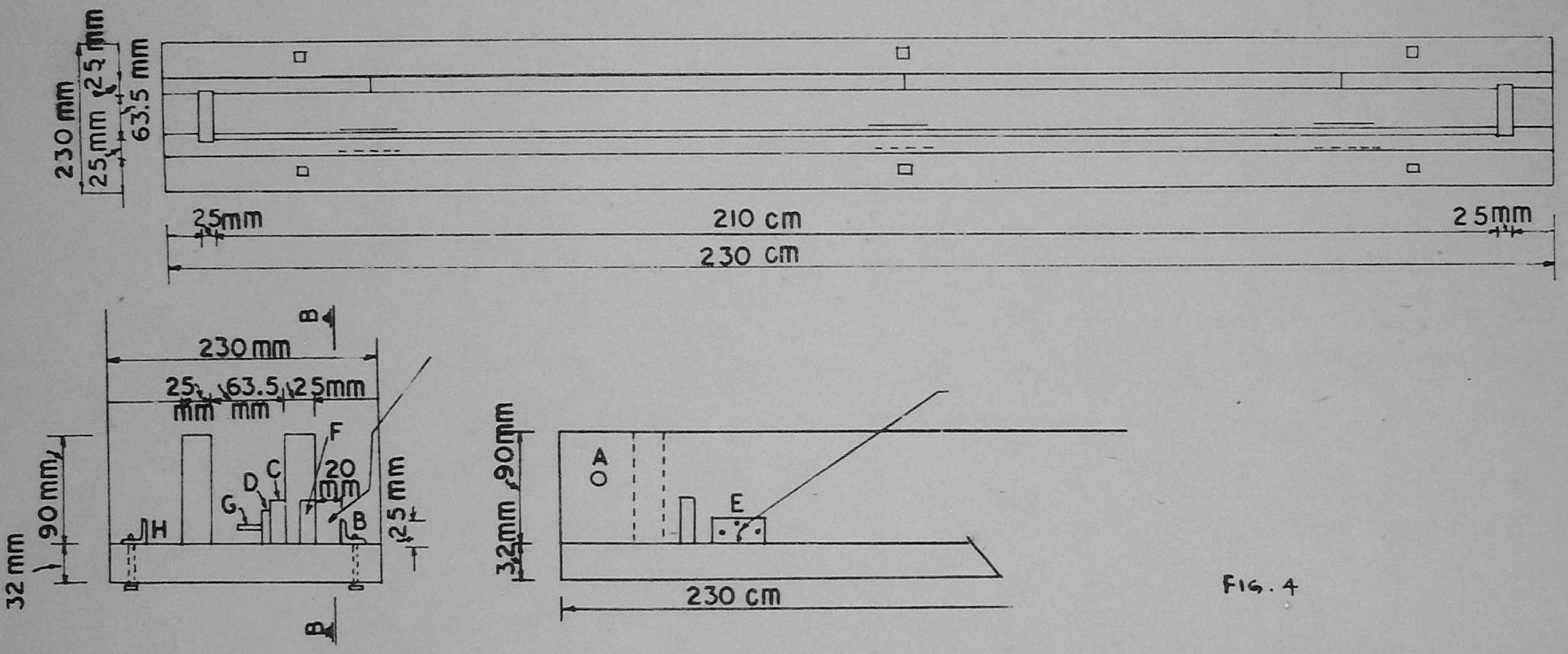

230 mm
25 mm
25 mm
63.5 mm
25mm
210 cm
25mm
230 cm
230 mm
25 mm
63.5 mm
25mm
B
F
20 mm
C
D
G
H
B
90 mm
32 mm
25 mm
A
E
90mm
32mm
230 cm

FIG. 4

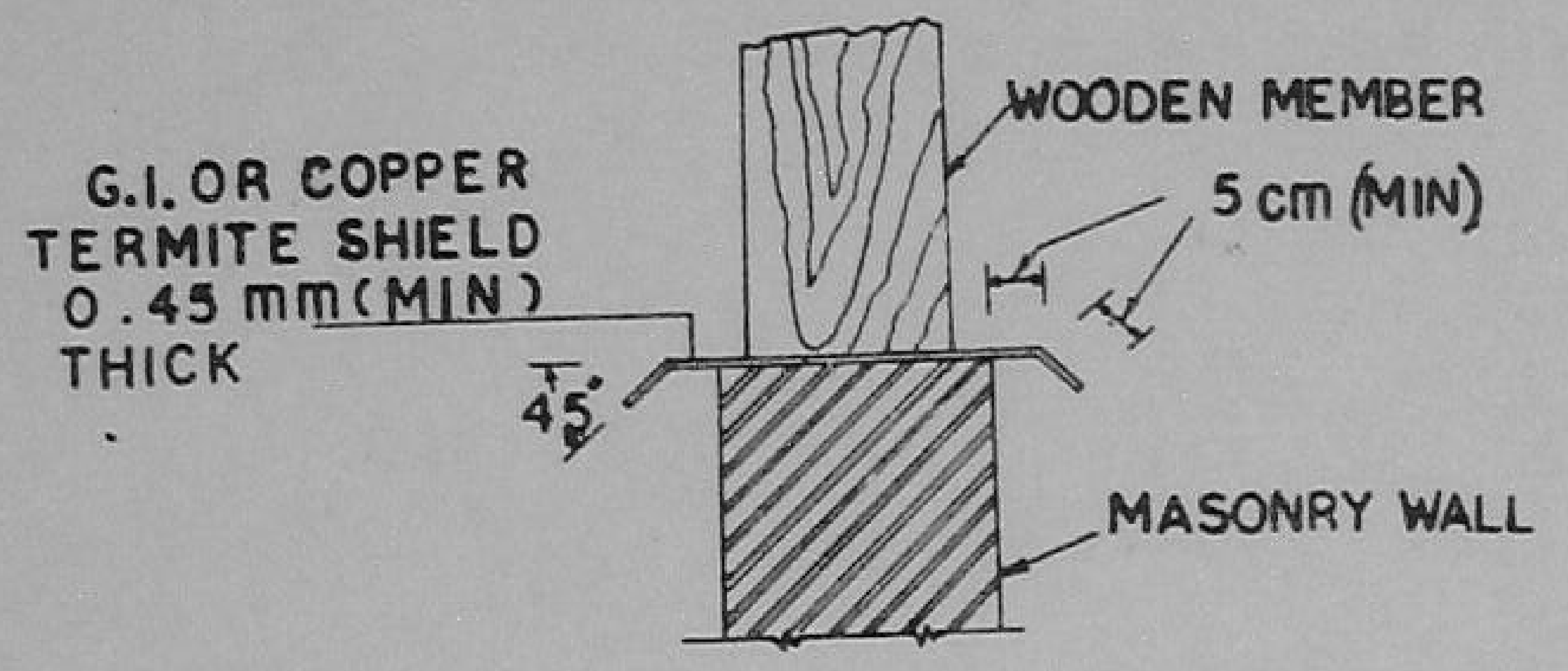


FIG. 5. TERMITE SHIELD.

10 Design Tables

10.1 General

10.1.1 This chapter gives design tables in simplified form for the use of technical personnel in rural areas.

10.2 Earth Walls

10.2.1 The thickness of sun-dried or mud walls should be at least twice the thickness required for masonry walls and that of stabilized soil walls 1½ times the thickness of masonry walls.

10.3 Permissible Stresses for Masonry

10.3.1 *Permissible Stresses.*—The permissible stress in a masonry wall or column should depend upon the crushing strength of the units (bricks, blocks or stones), the grade of mortar used, and the slenderness ratio of the wall or column in the following manner:

(a) *When the slenderness ratio of the member is unity or less*—The stress in a masonry wall or column due to combined dead and imposed loading considered as uniformly distributed over the area sustaining the load, should not exceed that given in Table 1.

Interpolation for units whose strength lies between those given in Table 1 is permissible but interpolation should not be used for mortars of compositions intermediate between those specified.

(b) *When the slenderness ratio exceeds unity.*—The permissible stress should be the product of the stress permitted for a slenderness ratio of unity, multiplied by the factor given in Table 2.

(c) *Allowances for the slenderness of the units themselves*—The figures for permissible stress given in Table 1 are suitable when the units are bricks, or blocks of similar proportions, but may be necessarily low for units whose ratio of height to thickness is greater than that of bricks. In the case of concrete blocks and other blocks with a height of not less than twice the thickness, the basic stresses may be increased by doubling the factors given in Table 2; the factors thus obtained being subject to a maximum of one.

TABLE 1

MAXIMUM PERMISSIBLE UNIFORMLY DISTRIBUTED COMPRESSIVE STRESSES ON MASONRY MEMBERS WITH SLENDERNESS RATIO OF UNITY

(Adopted from B.S.C.P. 111 (1948) and IS: 1905-1961)

Mortar Mix (Parts by Volume not Weeker than)			Age after Completion of Work (Days)	Maximum Uniformly Distributed Stress in kg/sq cm Corresponding to Units or Bricks and Blocks with a Crushing Strength in kg/sq cm of						Remarks
Cement	Lime	Sand		35	70	105	210	280	350	
1	..	3	7	3·5	7·0	10·5	15.0	17·5	25·5	IS 'B' or 'C' Class Lime
1	0-1/4	4	14	3·5	7·0	10·0	13·5	16·0	18·5	"
1	1	6	14	3·5	7·0	10·0	13·5	16·0	18·5	"
1	2	9	14	3·5	5·5	8·5	12·0	15·0	17·5	"
1	..	6	14	3·5	5·5	8·5	12·0	15·0	17·5	"
1	3	12	14	2·5	5·0	7·0	9·0	12·0	14.0	"
..	1	2	14	2·5	5·0	7·0	9·0	12·0	14·0	IS 'A' Class lime
..	1	2 to 3	28	2·5	4·0	5·5	7·0	7·0	7·0	IS 'B' or 'C' Class lime

NOTES:— (1) Liner interpolation may be made for units when crushing strengths are intermediate between those given.

(2) All stresses are for concentric loads and for a slenderness ratio of unity.

TABLE 2

REDUCTION FACTORS FOR SLENDERNESS RATIO

Slenderness ratio	Factor	Slenderness ratio	Factor
1	1·0	12	0·50
2	0·96	14	0·40
4	0·88	16	0·35
6	0·80	18	0·30
8	0·70	21	0·25
10	0·60	24	0·20

10.3.2. *Stresses due to Eccentric Loads or Lateral Forces*—Where there are additional stresses due to eccentricity of loading and /or lateral forces, the maximum stresses due to distributed loading, may exceed the permissible stresses given in para 10.3.1 by not more than 25 per cent, provided such excess is solely due to eccentricity of loading and/or lateral forces.

No reliance should be placed on the tensile strength of masonry in the calculations.

10.3.3 *Stresses due to Concentrated Loads*—Additional stresses of a purely local nature, as at girder bearings, column bases, lintels or other concentration of load, should be calculated as uniformly distributed pressures under the contact area and the maximum stress resulting from a combination of these with those caused by normal loads, eccentricity, lateral forces, etc, should not exceed the permissible stress given in para 10.3.1 by more than 50 per cent.

10.4 Reinforced Concrete Structures

10.4.1 Tables 3 to 13 give data for the design of reinforced concrete slabs, beams, columns, etc.

TABLE 3

PERMISSIBLE STRESSES FOR CONCRETE

Concrete Mix	Permissible Stress in Compression kg/sq cm		Permissible Stress in Tension kg/sq cm	Permissible Stress in Bond kg/sq cm		Permissible Bring Pressure on Full Area kg/sq cm (Plain Concrete only)
	Bending	Direct		Average	Local	
1:1:2	80	60	8	9	15	50
1:1½:3	70	50	7	8	13	40
1:2:4	50	40	5	6	10	30

TABLE 4

PERMISSIBLE STRESSES IN STEEL REINFORCE MENT

Type of Stress	Mild Steel to Grade 1 of IS: 432-1960 or to IS: 1139-1959
	kg/cm²
1. Tension other than in helical reinforcement in a column or in shear reinforcement	
(a) up to and including 40 mm . .	1400
(b) over 40 mm	1300
2. Tension in helical reinforcement in a column	1000
3. Tension in shear reinforcement in beams	1400
4. Compression in column bars . .	1300
5. Compression in bars in a beam or slab where the compressive resistance of concrete is not taken into account	
(a) up to and including 40 mm . .	1400
(b) over 40 mm	1300

TABLE 5

DESIGN CONSTANTS FOR VARIOUS CONCRETE MIXES AND THE USUAL PERMISSIBLE STRESS IN REINFORCEMENT FOR A BALANCED DESIGN

Mix	fc kg/sq cm	t kg/sq cm	m	n	j	q
1:1:2	80	1400	11·7	0·400	0·867	13·9
1:1½:3	70	1400	13·3	0·400	0·867	12·1
1:2:4	50	1400	18·7	0·400	0·867	8·7

Where

fc— Permissible compressive stress in concrete in bending,

t— Permissible tensile stress in reinforcement,

m— Modular ratio—2800/3fc

n— Neutral axis ratio,

j— Lever arm ratio, and

Q— M/bd^2

TABLE 6

WEIGHTS, PERIMETERS AND AREAS OF METRIC ROUND STEEL BARS

Bar Diameter mm	Weight per meter kg	Area and Perimeter	Number of Bars 1	2	3	4	5	6	7	8	9	10
5	0·15	Area (cm^2)	0·20	0·39	0·59	0·79	0·98	1·18	1·37	1·57	1·77	1·96
		Perimeter (cm)	1·57	3·14	4·71	6·28	7·85	9·43	11·00	12·57	14·14	15·71
6	0·22	Area (cm^2)	0·28	0·56	0·85	1·13	1·41	1·70	1·98	2·26	2·54	2·83
		Perimeter (cm)	1·88	3·77	5·66	7·54	9·43	11·31	13·20	15·08	16·97	18·85
8	0·39	Area (cm^2)	0·50	1·00	1·50	2·01	2·51	3·01	3·52	4·02	4·52	5·03
		Perimeter (cm)	2·51	5·03	7·54	10·05	12·57	15·08	17·59	20·11	22·62	25·13
10	0·62	Area (cm^2)	0·79	1·57	2·36	3·14	3·93	4·71	5·50	6·28	7·07	7·85
		Perimeter (cm)	3·14	6·28	9·42	12·57	15·71	18·85	21·99	25·13	28·27	31·42
12	0·89	Area (cm)	1·13	2·26	3·39	4·52	5·65	6·79	7·92	9·05	10·18	11·31
		Perimeter (cm)	3·77	7·54	11·31	15·08	18·85	22·62	26·39	30·16	33·93	37·70
16	1·58	Area (cm)	2·01	4·02	6·03	8·04	10·05	12·06	14·07	16·08	18·10	20·11
		Perimeter (cm)	5·03	10·05	15·08	20·11	25·13	30·16	35·19	40·22	45·24	50·27
20	2·47	Area (cm^2)	3·14	6·28	9·42	12·57	15·71	18·84	21·99	25·14	28·28	31·42
		Perimeter (cm)	6·28	12·57	18·85	25·13	31·42	37·70	43·98	50·27	56·55	62·83
25	3·85	Area (cm)	4·91	9·82	14·73	19·64	24·54	29·45	34·36	39·27	44·18	49·09
		Perimeter (cm)	7·85	15·71	23·56	31·42	39·27	47·12	54·99	62·83	70·68	78·54
28	4·83	Area (cm^2)	6·16	12·31	18·47	24·63	30·79	36·94	43·10	49·26	55·42	61·58
		Perimeter (cm)	8·80	17·59	26·39	35·19	43·98	52·78	61·58	70·37	79·17	87·97

TABLE 7

AREAS OF ROUND STEEL BARS FOR VARIOUS SPACING

Spacing (cm)	Area in cm² per metre Width of Slab for Bar Diameter of:				
	6 mm	8 mm	10 mm	12 mm	16 mm
6·0	4·71	8·38	13·09	18·85	33·52
6·5	4·35	7·73	12·08	17·40	30·93
7·0	4·04	7·18	11·22	16·16	28·73
7·5	3·77	6·70	10·47	15·08	26·81
8·0	3·53	6·28	9·82	14·14	25·14
8·5	3·33	5·91	9·24	13·31	23·66
9·0	3·14	5·59	8·73	12·57	22·34
9·5	2·98	5·29	8·27	11·90	21·17
10·0	2·83	5·03	7·85	11·31	20·11
10·5	2·69	4·79	7·48	10·77	19·15
11·0	2·57	4·57	7·14	10·28	18·28
11·5	2·46	4·37	6·83	9·84	17·49
12·0	2·36	4·19	6·54	9·42	16·76
12·5	2·26	4·02	6·28	9·05	16·09
13·0	2·17	3·87	6·04	8·70	15·47
13·5	2·09	3·72	5·82	8·38	14·90
14·0	2·02	3·59	5·61	8·08	14·36
14·5	1·95	3·47	5·42	7·80	13·87
15·0	1·89	3·35	5·24	7·54	13·41
15·5	1·82	3·24	5·07	7·30	12·97
16·0	1·77	3·14	4·91	7·07	12·57
16·5	1·71	3·05	4·76	6·85	12·19
17·0	1·66	2·96	4·62	6·65	11·83
17·5	1·62	2·87	4·49	6·46	11·49
18·0	1·57	2·79	4·36	6·28	11·17
18·5	1·53	2·72	4·25	6·11	10·87
19·0	1·49	2·65	4·13	5·95	10·58
19·5	1·45	2·58	4·03	5·80	10·31
20·0	1·41	2·51	3·93	5·65	10·05

TABLE 8

STRUCTURAL DETAILS OF SOLID SLABS OF DIFFERENT THICKNESSES

Thickness of Slab	Cover from centre of steel	Effective depth	Resisting moment per metre width	Area of main reinforcement required per metre width for a balanced design	Arrangements of Main Reinforcement			Arrangement of Distribution reinforcement	
					Bar diametre	Spacing	Area of steel actually provided per metre width	Bar diametre	Spacing
(cm)	(cm	(cm)	(kg cm)	(sq cm)	(mm)	(cm)	(sq cm)	(mm)	(cm)
8	2	6	31,300	4·30	10	18	4·36	6	17
9	2	7	42,600	5·00	12	22	5·13	8	27
10	2	8	55,700	5·80	12	19	5·95	8	25
11	2	9	70,500	6·50	12	17	6·65	8	22
12	2	10	87,000	7·20	12	15	7·54	8	20
13	2	11	1,05,300	7·90	12	14	8·08	8	19
14	3	11	1,05,300	7·90	16	25	8·02	10	23
15	3	12	1,25,300	8·60	16	23	8·73	10	26
16	3	13	1,47,000	9·30	16	21	9·56	12	35
17	3	14	1,70,500	10·10	20	31	10·10	12	33
18	3	15	1,95,700	10·70	20	29	10·80	12	31
19	3	16	2,22,700	11·50	20	27	11·62	12	29
20	3	17	2,51,400	12·20	20	25	12·55	12	28

TABLE 9

SAFE DISTRIBUTED SUPERIMPOSED LOADS FOR SOLID SLABS SIMPLY SUPPORTED AT BOTH ENDS

Thickness of slab (cm)	Safe superimposed load in kg/sq m for various spans in metres														
	1·50	1·75	2·00	2·25	2·50	2·75	3·00	3·25	3·50	3·75	4·00	4·25	4·50	4·75	5·00
8 .	930	635	440	310	220	150	..	..	..	..	..	..	..	..	..
9 .	1305	905	645	465	340	245	170	115	..	..	..	..	..	..	..
10 .	1750	1225	885	650	485	360	265	190	135	..	..	..	..	..	..
11 .	2255	1590	1155	860	650	495	375	280	205	150	..	..	..	..	..
12 .	..	1995	1465	1100	835	645	495	380	290	220	160	..	..	..	..
13 .	..	..	1805	1360	1050	810	635	495	390	300	225	165	..	..	..
14 .	..	..	1785	1340	1025	790	615	475	365	280	205	145	..	..	..
15 .	..	..	2160	1635	1260	980	770	605	475	370	280	210	150	..	..
16 .	..	..	..	1955	1510	1185	940	745	590	465	365	280	210	155	..
17 .	..	..	..	2305	1790	1410	1125	900	720	575	460	365	280	215	155
18 .	..	..	..	..	2095	1650	1325	1065	865	700	565	470	360	280	210
19 .	..	..	..	..	2415	1925	1540	1250	1020	830	675	550	440	350	275
20 .	..	..	..	..	..	2200	1770	1440	1180	970	795	650	530	430	345

TABLE 10

STRUCTURAL DETAILS AND RESISTING MOMENTS OF RECTANGULAR BEAMS

Size of beam b×D (cm×cm)	Cover from centre of steel (cm)	Effective depth (cm)	Approximate moment of resistance (kg cm)	Area of main reinforcement required (sq cm)	Details of reinforcement: Bar diameter (mm)	Details of reinforcement: No. of bars
1	2	3	4	5	6	7
15×15	3	12	18,800	1·29	8	3
15×20	3	17	37,700	1·83	10 6	2 1
15×25	3	22	63,200	2·36	10	3
15×30	3	27	95,100	2·90	12 10	2 1
15×35	3	32	1,33,700	3·44	12	3
15×40	3·5	36·5	1,74,000	3·92	16	2
15×45	3·5	41·5	2,24,000	4·43	16 8	2 1
20×20	3	17	0,300	2·44	10 8	2 2
20×25	3	22	84,200	3·15	10	4
20×30	3	27	1,26,900	3·87	10	5
20×35	3	32	1,78,100	4·58	12 10	3 2
20×40	3·5	36·5	2,32,000	5·22	16 10	2 2
20×45	3·5	41·5	3,00,000	5·95	16	3
20×50	3·5	46·5	3,76,000	6·65	20 10	2 1
20×55	3·5	51·5	4,61,000	7·36	16	4
20×60	3·5	56·5	5,56,000	8·10	16 12	3 2
25×25	3	22	1,05,200	3·94	10	5
25×30	3	27	1,58,200	4·83	12 10	2 4
25×35	3	32	2,22,800	5·74	16	3
25×40	3	37	2,97,800	6·61	12	6
25×45	3·5	41·5	3,75,000	7·43	16	4
25×50	3·5	46·5	4,70,000	8·32	20 12	2 2
25×55	3·5	51·5	5,76,800	9·20	16 10	4 2
25×60	3·5	56·5	6,94,000	10·20	16 12	4 2
25×65	3·5	61·5	8,22,600	11·00	20 10	3 2
25×70	3·5	66·5	9,62,000	11·90	16	6

TABLE 10—Contd.

Size of beam b×D (cm×cm)	Cover from centre of steel (cm)	Effective depth (cm)	Approximate moment of resistance (kg cm)	Area of main reinforcement required (sq cm)	Details of reinforcement: Bar diameter (mm)	Details of reinforcement: No. of bars
1	2	3	4	5	6	7
30×30	3·5	26·5	1,83,500	5·70	16	3
30×35	3·5	31·5	2,59,500	6·77	12	6
30×40	3·5	36·5	3,48,000	7·85	16	4
30×45	3·5	41·5	4,50,000	8·83	16 10	4 1
30×50	3·5	46·5	5,64,000	10·00	16	5
30×55	3·5	51·5	6,84,000	10·95	20 10	3 2
30×60	3·5	56·5	8,32,500	12·15	20	4
30×65	3·5	61·5	9,89,000	13·25	20 10	4 1
30×70	3·5	66·5	11,54,000	14·30	20 12	4 2
30×75	3·5	71·5	13,35,000	15·35	20	5

TABLE 11

DISTANCE (x) FROM SUPPORTS REQUIRING SHEAR REINFORCEMENT IN BEAMS

(FOR PERMISSIBLE SHEAR STRESS IN CONCRETE OF 5 kg/sq cm)

(Figures tabulated give value of **x** *in cm)*

Span (m) / End shear stress (kg/sq cm)	3·00	3·25	3·50	3·75	4·00	4·25	4·50	4·75	5·00	5·25	5·50	5·75	6·00	6·25	6·50
20·0	113	122	131	140	150	160	169	179	188	197	207	216	225	235	244
19·5	112	121	131	140	149	158	168	177	186	196	205	214	224	233	243
19·0	111	120	129	138	147	156	166	175	184	193	203	212	221	230	240
18·5	109	118	128	137	146	155	165	174	183	192	201	210	219	228	238
18·0	108	117	126	135	144	153	163	172	181	190	199	208	217	226	235
17·5	107	116	125	134	143	152	161	170	179	188	197	206	215	224	233
17·0	106	115	124	132	141	150	159	168	177	186	195	204	212	221	230
16·5	105	114	122	131	139	148	157	165	174	183	192	200	209	218	227
16·0	103	112	120	129	137	146	155	163	172	181	189	198	206	215	223
15·5	102	111	119	128	136	145	153	161	170	178	187	195	203	212	220
15·0	100	108	117	125	133	142	150	159	167	175	184	192	200	208	217
14·5	98	106	115	123	131	139	148	156	164	172	181	189	197	205	214
14·0	96	104	113	121	129	137	145	153	161	169	177	185	193	201	209
13·5	95	103	111	118	126	134	142	150	158	166	174	180	189	197	205
13·0	92	100	108	115	123	131	139	146	154	162	170	177	185	193	200
12·5	90	98	105	113	120	128	135	143	150	158	165	173	180	188	195
12·0	87	95	102	110	117	124	132	139	146	153	161	168	175	182	190
11·5	85	92	99	106	113	120	127	134	141	148	156	163	170	177	184
11·0	82	89	96	102	109	116	123	129	136	143	150	157	164	171	178
10·5	79	86	92	99	105	112	118	125	131	138	144	151	157	164	170
10·0	75	81	88	94	100	106	112	119	125	131	138	144	150	156	163
9·5	71	77	83	89	95	101	107	113	119	125	131	136	142	148	154
9·0	67	73	78	84	89	95	100	106	111	117	122	128	133	139	144
8·5	62	67	72	77	82	87	93	98	103	108	114	119	124	129	134
8·0	56	61	66	70	75	80	85	89	94	99	104	108	113	118	123
7·5	50	54	59	63	67	71	75	79	83	87	92	96	100	104	109
7·0	43	47	50	54	57	61	65	68	72	76	79	83	86	90	93
6·5	35	38	41	43	46	49	52	55	58	61	64	66	69	72	75
6·0	25	27	29	31	33	35	38	40	42	44	46	48	50	52	54
5·5	14	15	16	17	18	19	21	22	23	24	25	26	27	28	30

Example— For a beam spanning 4·00 m and with an end shear stress of 18·0 kg/sq cm, the beam requires shear reinforcement to a distance of 144 cm from the support.

TABLE 12

SHEAR RESISTANCE OF TWO LEGGED STIRRUPS AT VARIOUS SPACINGS

Stirrup size (mm)	Spacing of stirrups "p" in cm.																	
	5	7·5	10	12·5	15	17·5	20	22·5	25	30	35	40	45	50	55	60	65	70
		Value of $\frac{S}{jd} = \frac{At \times t}{p}$																
5	109	73	55	44	36	31	27	24	22	18	16	14	12	11	10	9	8	8
6	157	105	78	63	52	45	39	35	31	26	22	20	17	16	14	13	12	11
8	280	187	140	112	93	80	70	62	56	47	40	35	31	28	25	23	22	20
10	440	293	220	176	147	126	110	98	88	73	63	55	49	44	40	37	34	31
12	633	422	316	253	211	181	158	141	127	105	90	79	70	63	57	53	49	45

Where :—

S = Total shear force at a section in kg.

jd = lever arm in cm.

At = Area of both legs of stirrups in sq. cm.

t = permissible tensile stress in stirrups in kg/sq cm.

p = spacing of stirrups in cm.

TABLE 13

SAFE AXIAL LOADS ON SHORT SQUARE COLUMNS

(*Allowable steel stress*—1300 kg/sq cm)

Size	Vertical Steel		Area of steel	Stirrups		Safe load in tonnes
	No. of bars	Bar diameter		Bar diameter	Pitch	Concrete mix 1:2:4
cm x cm		mm	sq cm	mm	cm	
1	2	3	4	5	6	7
15 x 15	4	12	4·52	5	14	14·8
	6	12	6·79	5	14	17·6
	8	12	9·05	5	14	20·0
	4	16	8·04	5	15	19·2
	6	16	12·06	5	15	24·2
	8	16	16·08	5	15	30·2
20 x 20	4	12	4·52	5	14	21·7
	6	12	6·79	5	14	24·6
	8	12	9·05	5	14	27·4
	4	16	8·04	5	19	26·2
	6	16	12·06	5	19	31·2
	8	16	16·08	5	19	36·2
	4	20	12·57	5	20	31·8
	6	20	18·84	5	20	39·8
	8	20	25·14	5	20	47·6
	4	25	19·63	8	20	40·8
25 x 25	8	12	9·05	5	14	36·4
	4	16	8·04	5	19	35·2
	6	16	12·06	5	19	40·2
	8	16	16·08	5	19	46·2
	4	20	12·57	5	24	40·8
	6	20	18·84	5	24	48·8
	8	20	25·14	5	24	56·6
	4	25	19·63	8	25	49·8
	6	25	29·45	8	25	62·2
	8	25	39·27	8	25	74·4
	4	28	24·63	8	25	56·0
	6	28	36·94	8	25	71·6
	8	28	49·26	8	25	87·0
	4	32	32·17	8	25	65·6
30 x 30	8	12	9·05	5	14	47·4
	4	16	8·04	5	19	46·2
	6	16	12·06	5	19	51·2
	8	16	16·08	5	19	57·2
	4	20	12·57	5	24	51·8
	6	20	18·84	5	24	59·8
	8	20	25·14	5	24	67·6
	4	25	19·63	8	30	90·8
	6	25	29·45	8	30	73·2
	8	25	39·27	8	30	85·4
	4	28	24·63	8	30	67·0
	6	28	36·94	8	30	82·6
	8	28	49·26	8	30	98·0
	4	32	32·17	8	30	76.6
	6	32	48·26	8	30	96.8
	8	32	64·34	8	30	117.0
	4	36	40·72	10	30	87.2

10.5 Reinforced Brickwork

10.5.1 *General*—Reinforced brickwork is similar to reinforced concrete except that brickwork in cement mortar is used in place of cement concrete. It is suitable for use in small span floor slabs and lintels. It is not safe to use reinforced brickwork for long beams as its resistance to diagonal tension is very poor. Sometimes web reinforcement is provided in reinforced brickwork to increase its resistance to diagonal tension. It is advisable not to allow the diagonal tension to increase beyond 3 kg/sq cm even when web reinforcement is provided.

10.5.2 *Design of Reinforced Brick Slabs and Beams*—The principles of design of reinforced brick slabs and beams are similar to the design of reinforced concrete members except that working stresses and the modular ratio are different. Usually the following values are adopted for stresses and modular ratio:

(a) Permissible compressive stress in brickwork	fc=25 kg/sq cm
(b) Permissible tensile stress in reinforcement	t=1400 kg/sq cm
(c) Safe shear stress in brickwork	s=2 kg/sq cm
(d) Modular ratio	m=40

10.5.3 Only sound bricks of good quality should be used for R. B. work and the mortar should consist of 1 part cement to 3 parts of coarse clean sand. The bricks must be properly soaked in water before use, otherwise they will absorb water from the mortar and interfere in its curing. The diameter of steel bars should be kept as small as possible and the joints should be sufficiently wide so that mortar may be filled all round the bars. If the bars at any point due to lack of mortar come in contact with bricks, which are porous, they are liable to rust and get weaker.

10.6 Timber Trusses (Nail jointed)

10.6.1 This clause gives design details of nail-jointed timber trusses of 3 to 6 metres span. Trusses have been designed for 3 types of roofing materials and light weight ceiling.

(i) Light weight loading for C.G.I. sheets.

(ii) Medium weight loading for A.C. sheets.

(iii) Heavy weight loading for earthen tiles.

Wind loads have been taken into consideration according to IS:875-1957.

10.6.2 *Recommended Timber Species for Various types of Trusses*—Table 14 gives the recommended timber species for various types of trusses.

TABLE 14

RECOMMENDED TIMBER SPECIES FOR VARIOUS TYPES OF TRUSSES

Span	Drawing No.	Species Recommended
(a) FOR LIGHT WEIGHT ROOFS USING C.G.I. SHEETS WITH CEILING		
3 metres . . .	3L	Gamari, Anjan, Kumbi, Jack, Kaim or Kanju.
4 metres . . .	4L	Chir, Teak (M.P.), Deodar, Indian Chestnut, Indian Rosewood (Malabar) or Civit.
5 metres . . .	5L	Cypress, Teak (M.P.), Deodar, Sissoo, Mahua, Sandan, Neem, Chir, Hollock, Haldu, Mango or White Siris.
6 metres . . .	6L	Mango, Teak (M.P.), Deodar, Indian Rosewood (Malabar), Sissoo (U.P.) Mahua, Sandan, Neem, Civit, Indian Chestnut, Chir, Hollock or Haldu.
(b) MEDIUM WEIGHT ROOFS USING A.C. SHEETS WITH CEILING		
3 metres . .	3M	Gamari, Anjan, Kumbi, Jack, Kaim or Kanju.
4 metres . . .	4M	Chir, Teak (M.P.), Deodar, Civit, Indian Chestnut or Indian Rosewood.
5 metres . . .	5M	Cypress, Teak (M. P.), Deodar, Sissoo, Mahua, Sandan, Neem, Chir, Hollock, Haldu, Mango or White-Siris.
6 metres . . .	6M	Mango, Teak (M. P.), Deodar, Indian Rosewood (Malabar), Sissoo, Mahua, Sandan, Neem, Civit, Indian Chestnut, Chir, Hollock or Haldu.
(c) HEAVY WEIGHT ROOFS USING ORDINARY EARTHEN TILES WITH CEILING		
3 metres . . .	3H	Gamari, Anjan, Kumbi, Jack, Kaim or Kanju.
4 metres . . .	4H	Chir, Teak (M. P.), Indian Chestnut, Deodar, Civit or Indian Rosewood (Malabar).
5 metres . . .	5H	Cypress, Teak (M.P.), Deodar, Sissoo, Mahua, Sandan, Neem, Chir, Hollock, Haldu, Mango or White Siris.
6 metres . . .	6H	Mango, Teak (M. P.), Deodar, Indian Rosewood (Malabar), Sissoo, Mahua, Sandan, Neem, Civit, Indian Chestnut, Chir, Hollock or Haldu.

10.6.3 *Method of Using Typical Design*—Roof trusses have been designed for loading as per Indian Standards or as found suitable in actual practice. Spacings between the trusses have also been mentioned on the drawings. In case lighter loads than those mentioned in the drawings are experienced in actual practice, the spacings of the trusses may be increased proportionately.

10.6.4 *Nailed Joints*—Two types of nailed joints are usually employed:

1. Lap Joints,
2. Butt Joints.

In a lap joint the nails are in single shear whereas they are in double shear in a butt joint. To take advantage of the greater strength, it is general practice to go in for butt joints with the help of fish plates, etc.

10.6.5 Table 15 gives the value of lateral strengths of nails of 3.55 mm diameter in double shear.

TABLE 15

INTERIM VALUES OF LATERAL STRENGTHS OF NAILS OF 3·55 mm DIAMETER IN DOUBLE SHEAR

Sl. No.	Trade Name	For Permanent constructions—Strength per Nail in kg		For Temporary Constructions Strength per Nail in kg For both Lengthening and Node Joints
		Lengthening Joints	Node Joints	
1	2	3	4	5
*1.	FIR(S)	80	20	120
*2.	DEODAR (S)	90	40	150
*3.	KAIL(S)	70	30	90
4.	JAMUN(H)	150	120	250
5.	SANDAN (H)	170	110	180
6.	HOLLOCK (H)	130	100	190
7.	PADAUK (H)	190	140	230
8.	KOKO (H)	200	70	200
9.	WHITE CHUGLAM (H)	180	90	190
10.	HOLLONG (H)	170	70	200
11.	CHICKRASSY (ANDAMAN) (H)	240	80	270
12.	GURJAN (ANDAMAN) (H)	190	90	190
13.	BLACK CHUGLAM (H)	230	100	230
14.	SAIN (H)	160	160	290
15.	SAL (U.P.) (H)	100	50	190
16.	BAHERA (H)	100	100	140
17.	BIJASAL (H)	150	120	170
18.	AXLE WOOD (H)	200	100	290
19.	BLACK SIRIS (H)	140	50	220
20.	CHIR (S)	110	100	160
21.	CYPRESS (H)	60	50	180
22.	DHAMAN (H)	130	50	240
*23.	MANGO (S)	110	90	160
24.	LENDI (H)	190	50	260
*25.	TOON (S)	150	100	180
*26.	BONSUM (S)	120	60	130
27.	TEAK (FRI) (H)	140	80	130
*28.	CAMPHOR (CINNAMON) (H)	120	90	130
29.	KUSUM (H)	230	160	400
30.	POON (H)	160	90	210
31.	OAK (H)	110	110	270
*32.	CHAMPA (S)	130	90	200
33.	MESUA (H)	260	80	410
34.	BABUL (H)	150	110	340
35.	EUCALYPTUS (H)	170	100	300
36.	IRUL (H)	230	60	330
37.	GENDHALIPOMA (S)	100	80	210

* Species require no pre-boring for nail penetration; H—Hardwood S—Softwood

10.6.6 *Spacing and Edge Distances of Nails Driven with Pre-bored Holes*

End distance—10D

Edge distance—5D

Side spacing between lines of nails—3D

Spacing between adjacent nails—10D

Where D=diameter of nails.

10.6.7 *Method of Driving Nails*—In some softwoods, it is possible to drive nails without any prebore. In hardwoods and some softwoods prebore of the following diameter should be drilled first and the nails driven into the prebore.

Hardwoods—Diameter of the prebore to be less by at least two gauges of the nail diameter, *i.e.*, for 8 S.W.G. nails prebore will be 10 S.W.G.

Softwoods—Diameter of the prebore to be less by at least 3 gauges of the nail diameter.

Diamond pointed nails are the best for constructional work.

10.6.8 *Quantities of Materials*—Table 16 gives quantities of timber and nails for nail-jointed timber trusses of various spans per 100 sq m of covered ground area.

10.6.9 *Typical Designs*—Data and design of timber trusses are given on the following pages.

TABLE 16

QUANTITIES OF TIMBER AND NAILS REQUIRED FOR TRUSSES AND PURLINS ETC PER 100 SQ M OF GROUND AREA (COVERED) FOR DIFFERENT SPANS

Span	Timber for			Nails
	Truss (cu m)	Purlins (cu m)	Total (cu m)	kg
3-metre span				
(a) Light weight roofing using C. G. I. sheets with ceiling	0·38	2·14	2·52	9·3
(b) Medium weight roofing using A. C. sheets with ceiling	0·38	2·40	2·78	9·5
(c) Heavy weight roofing using earthen tiles with ceiling	0·49	4·77	5·26	20·6
4-metre span				
(a) Light weight roofing using C. G. I. sheets with ceiling	0·37	2·01	2·38	5·4
(b) Medium weight roofing using A. C. sheets with ceiling	0·39	2·41	2·80	9·3
(c) Heavy weight roofing using earthen tiles with ceiling	0·82	3·16	3·98	28·5
5-metre span				
(a) Light weight roofing using C. G. I. sheets with ceiling	0·40	1·78	2·18	7·7
(b) Medium weight roofing using A. C. sheets with ceiling	0·44	2·08	2·52	7·7
(c) Heavy weight roofing using earthen tiles with ceiling	0·88	3·62	4·50	15·8
6-metre span				
(a) Light weight roofing using C. G. I. sheets with ceiling	0·56	1·64	2·20	14·6
(b) Medium weight roofing using A. C. sheets with ceiling	0·56	1·74	2·30	14·6
(c) Heavy weight roofing using earthen tiles with ceiling	1·10	2·76	3·86	39·5

REFERENCES

(1) "Nailed Joints for Timber Structures" Part-I New Delhi, National Buildings Organisation.

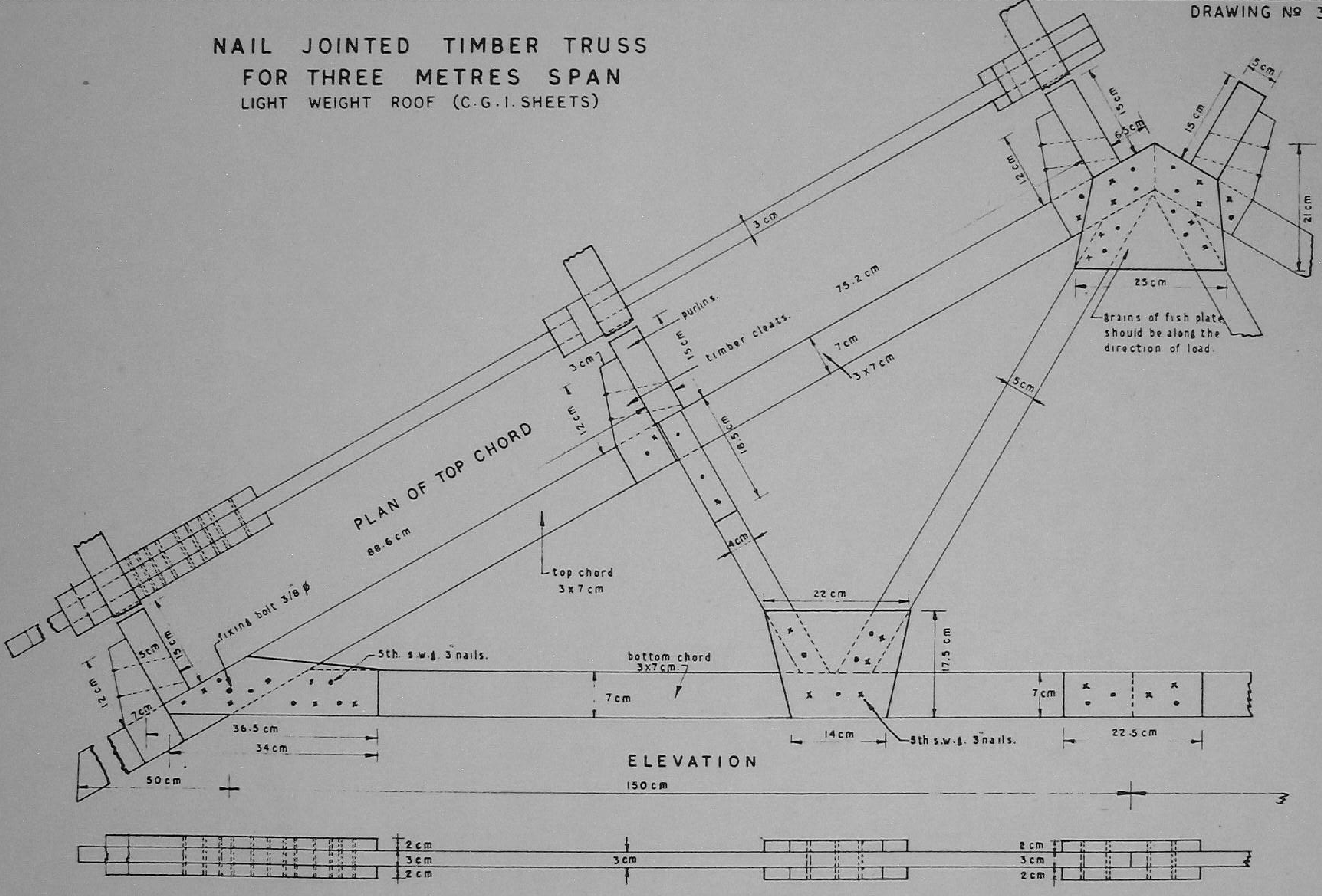
(2) "Typical Designs of Small Span Timber Trusses", New Delhi, National Buildings Organisation, 1963.

(3) "Nailed Joints in Timber Structures" Part-II New Delhi, National Buildings Organisation, 1963.

(4) "Handbook for Building Engineers in Metric System", New Delhi, National Buildings Organisation.

NAIL JOINTED TIMBER TRUSS FOR THREE METRES SPAN

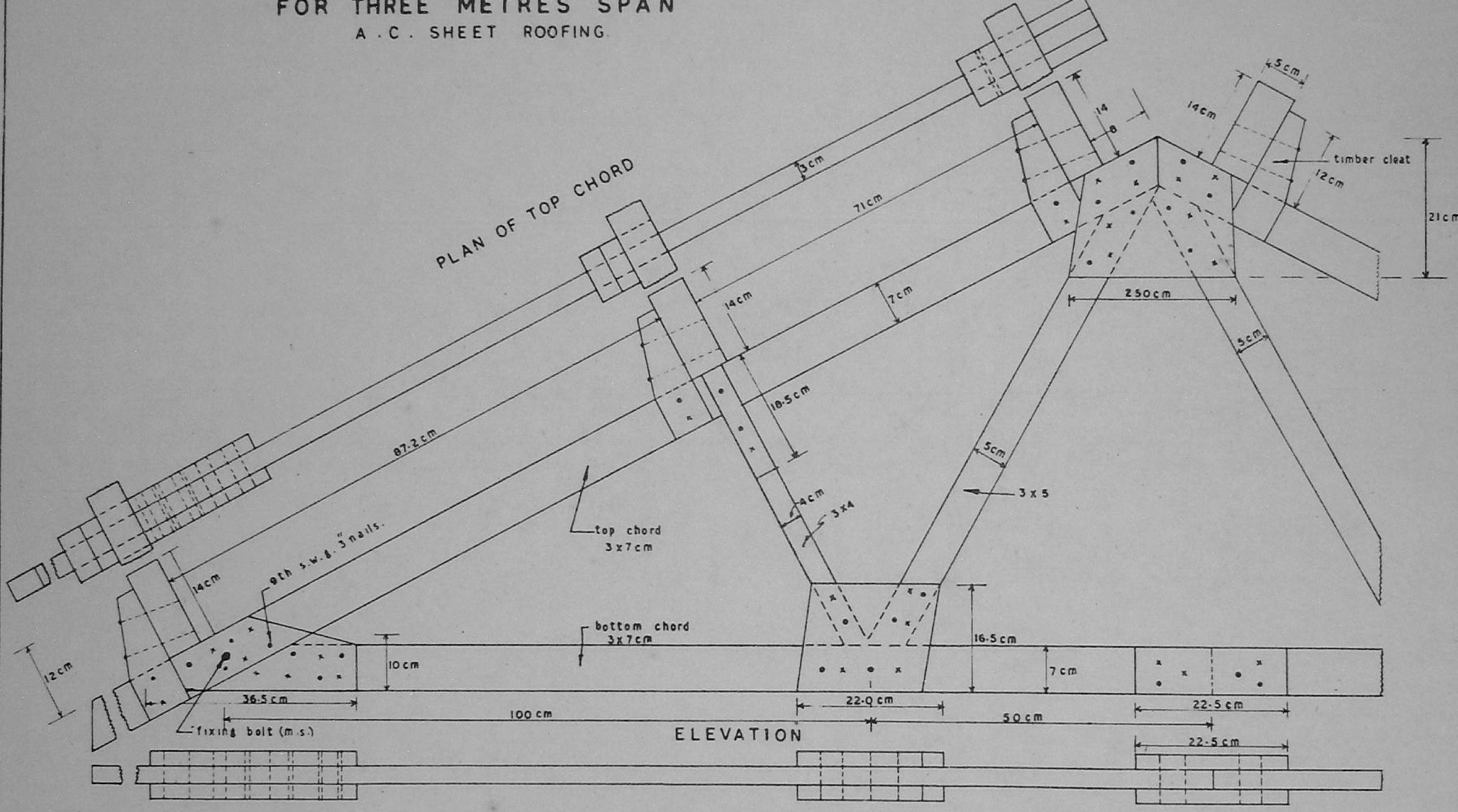
LIGHT WEIGHT ROOF (C.G.I. SHEETS)



DRAWING № 3M/1

NAIL JOINTED TIMBER TRUSS FOR THREE METRES SPAN

A.C. SHEET ROOFING.

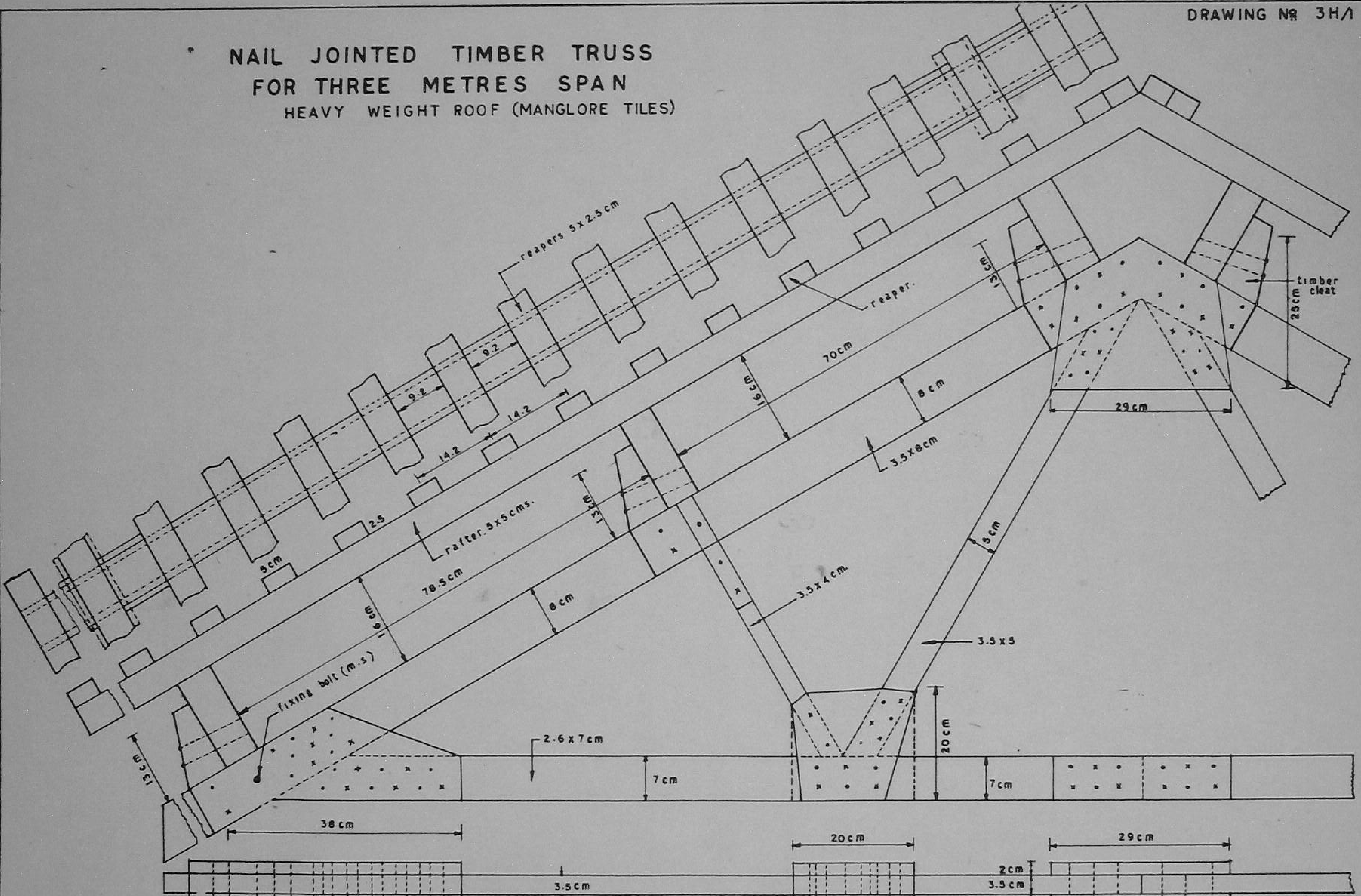


ELEVATION

PLAN OF BOTTOM CHORD

NAIL JOINTED TIMBER TRUSS FOR THREE METRES SPAN

HEAVY WEIGHT ROOF (MANGLORE TILES)

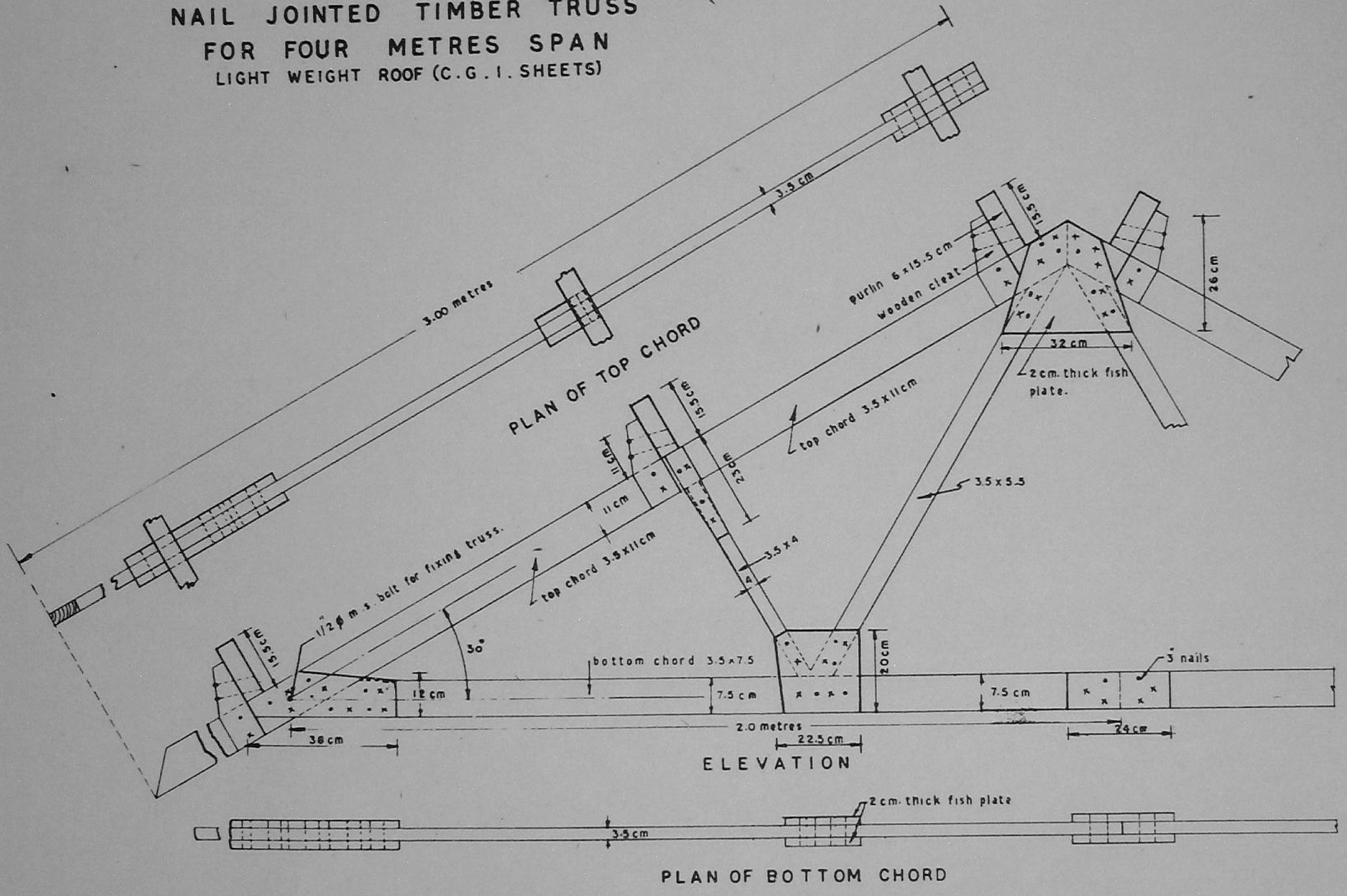


PLAN OF BOTTOM CHORD

DRAWING No. 4L/2

NAIL JOINTED TIMBER TRUSS FOR FOUR METRES SPAN

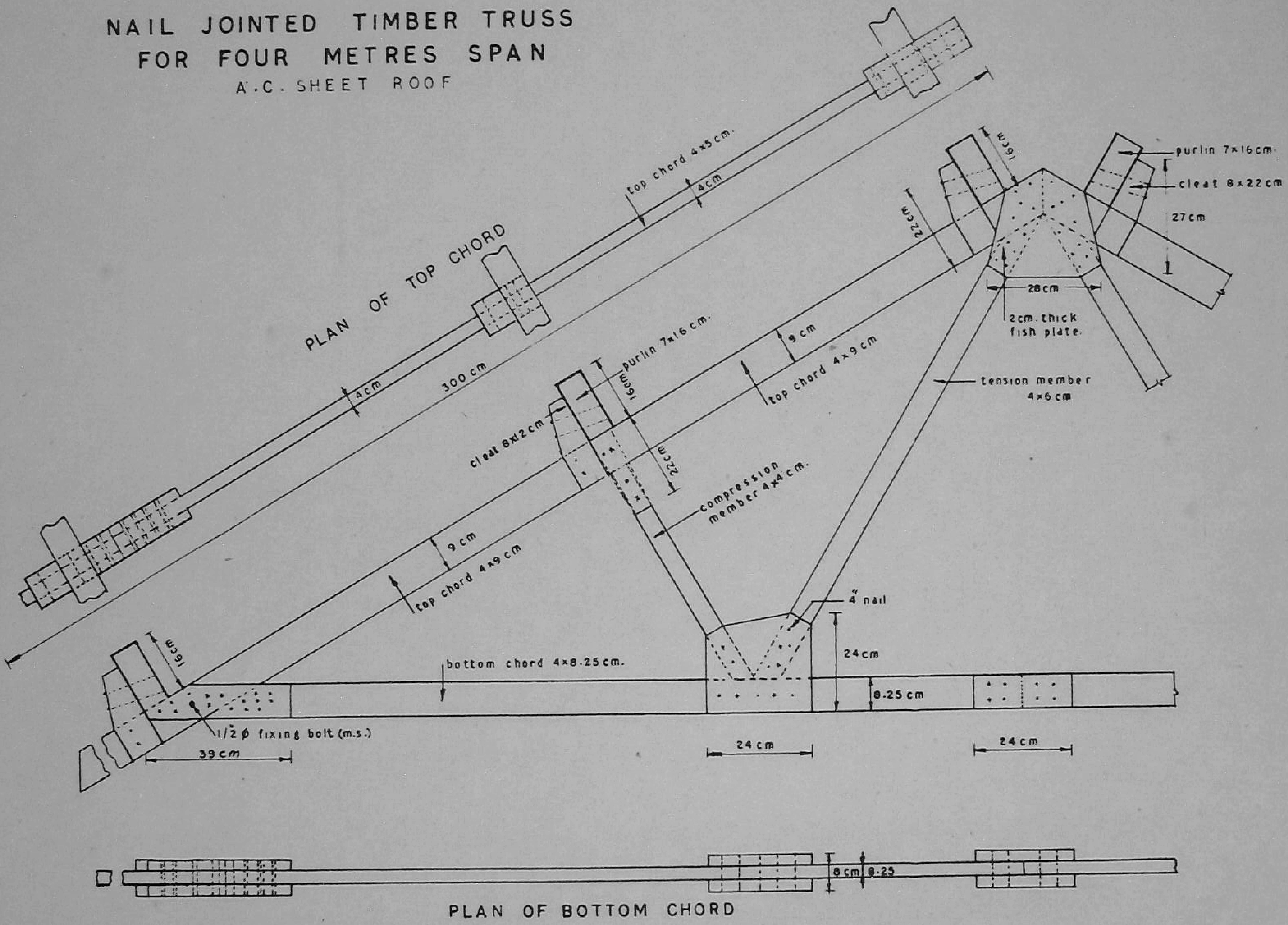
LIGHT WEIGHT ROOF (C.G.I. SHEETS)



DRAWING Nº 4M/1

NAIL JOINTED TIMBER TRUSS FOR FOUR METRES SPAN

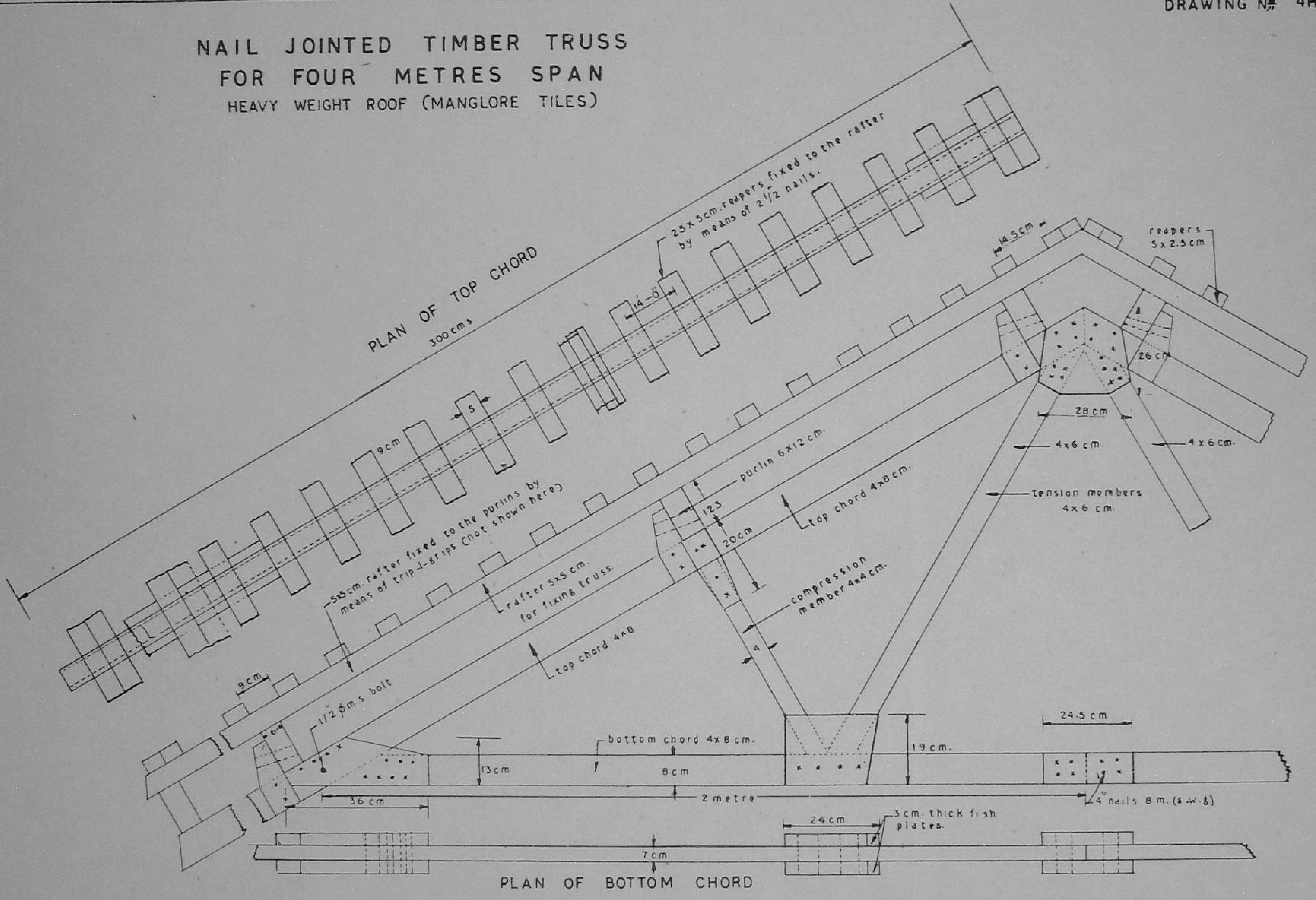
A.C. SHEET ROOF



DRAWING No. 4H/2

NAIL JOINTED TIMBER TRUSS FOR FOUR METRES SPAN

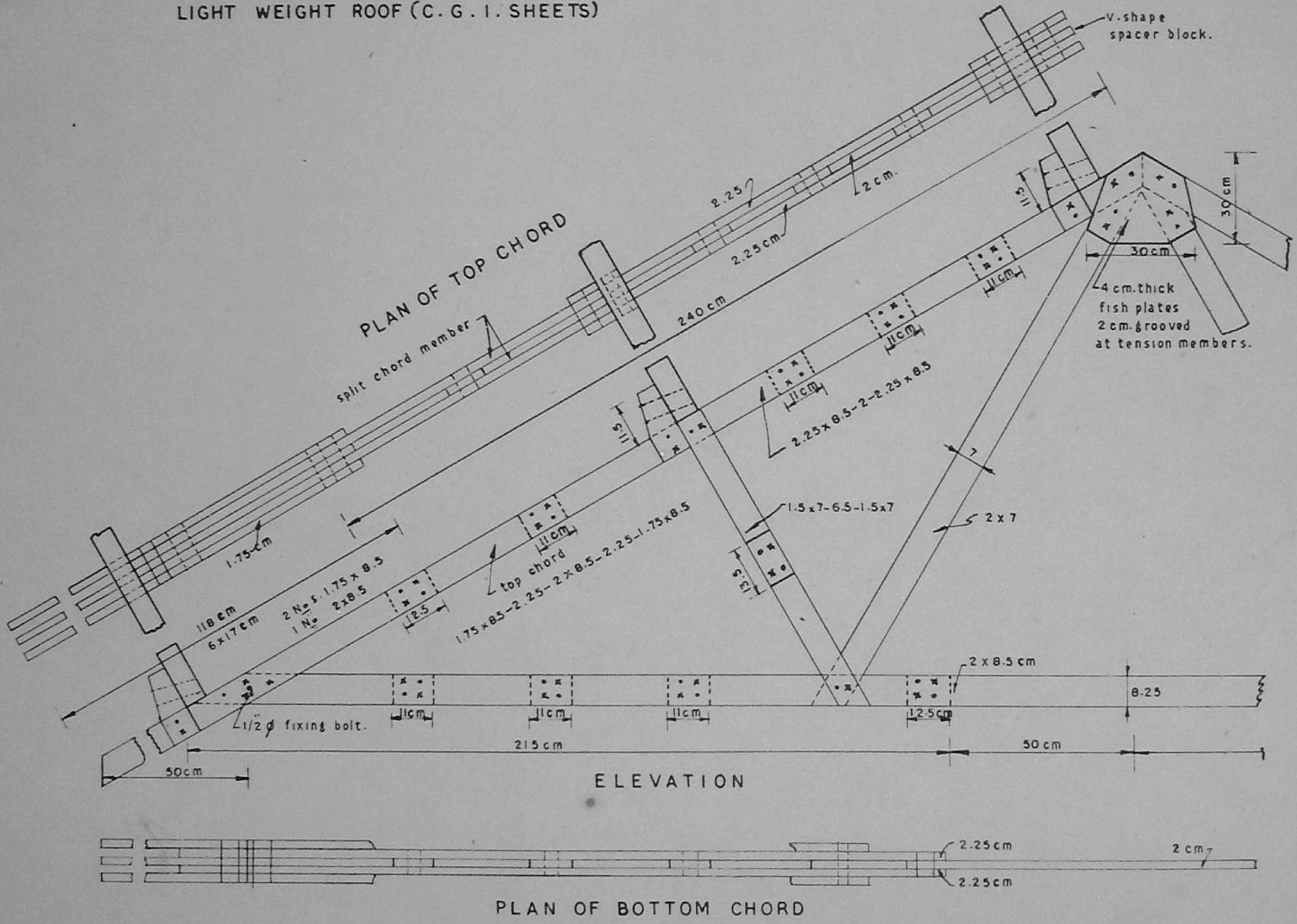
HEAVY WEIGHT ROOF (MANGLORE TILES)



DRAWING № 5L/2

NAIL JOINTED TIMBER TRUSS FOR FIVE METRES SPAN

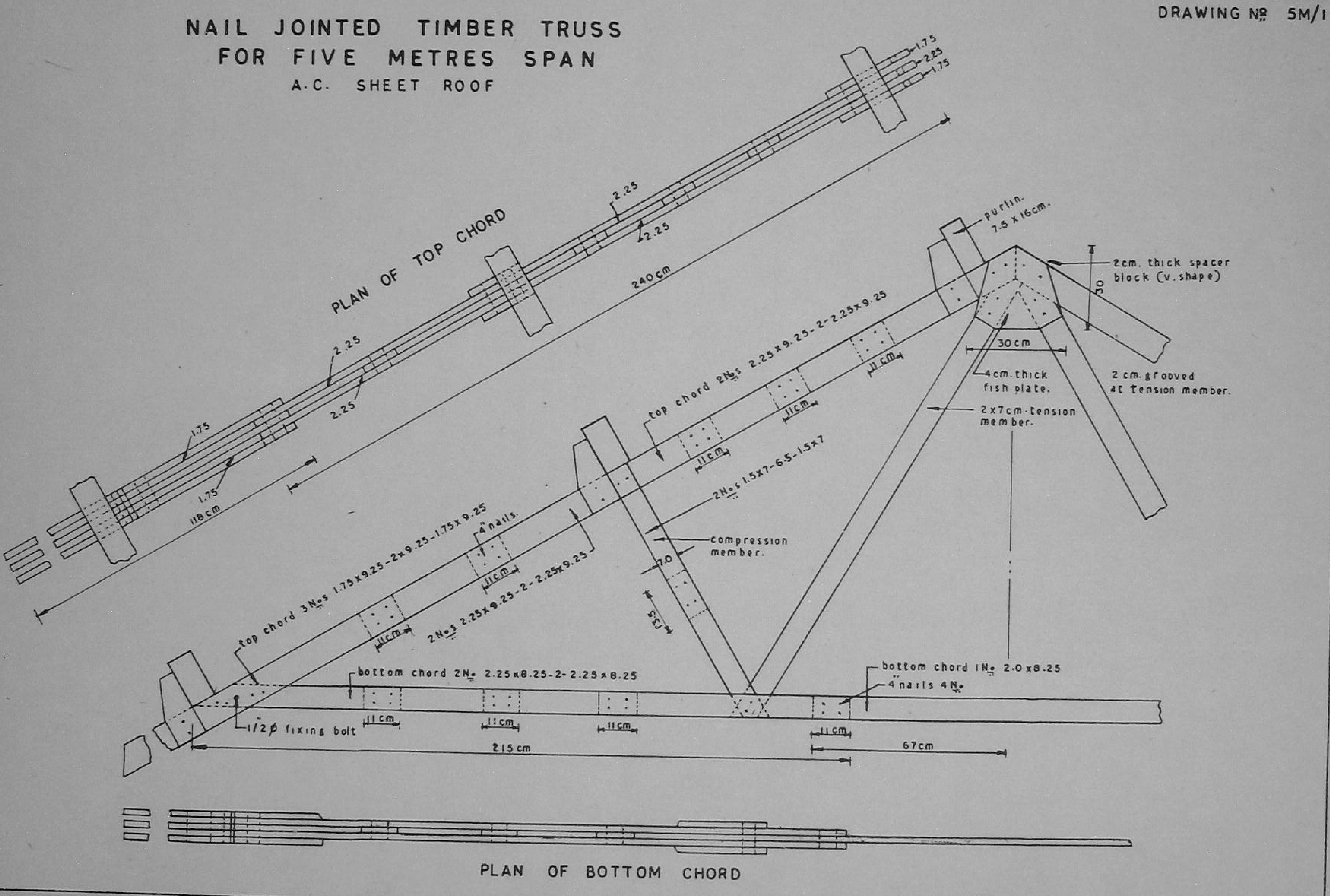
LIGHT WEIGHT ROOF (C. G. I. SHEETS)



DRAWING No. 5M/1

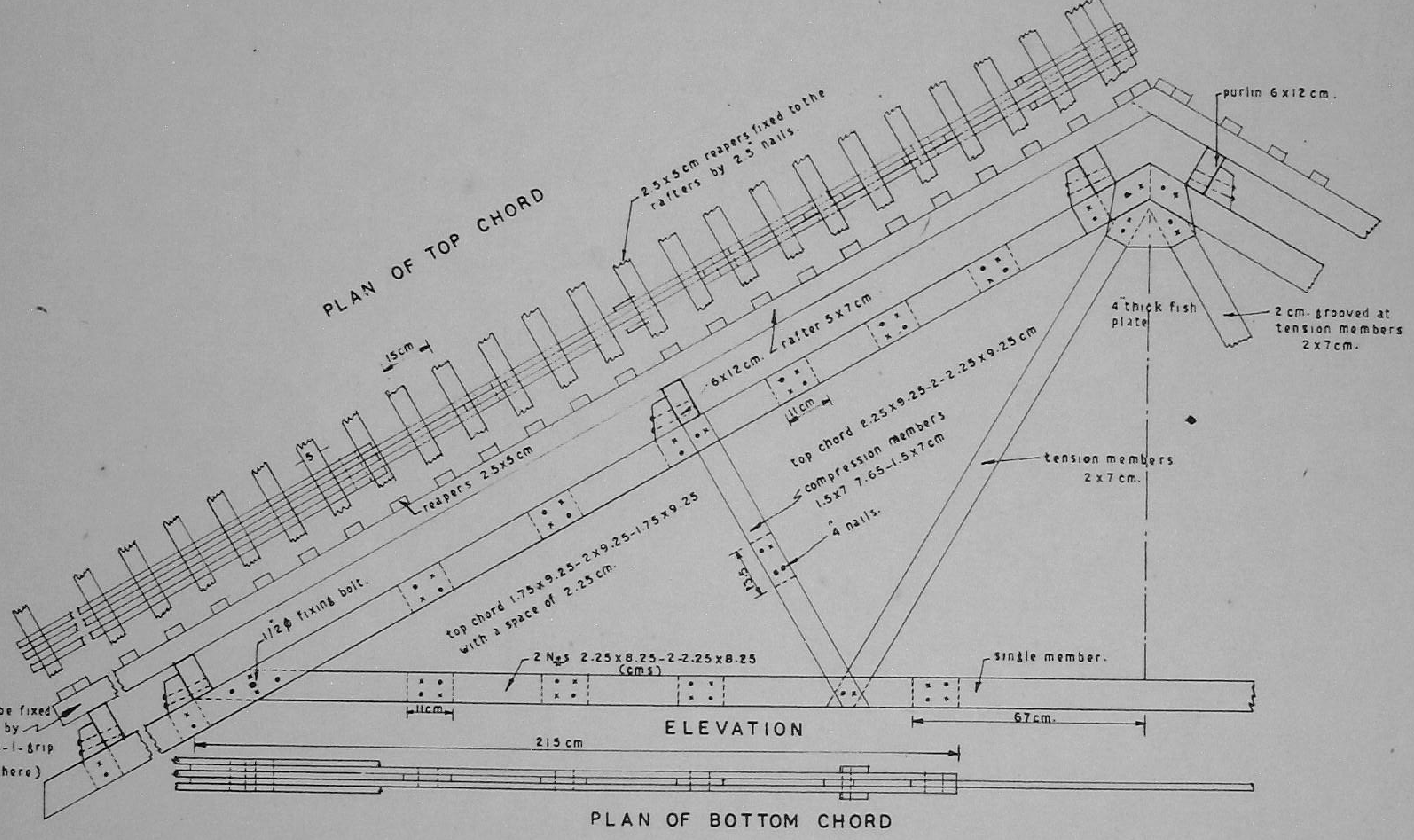
NAIL JOINTED TIMBER TRUSS FOR FIVE METRES SPAN

A.C. SHEET ROOF



NAIL JOINTED TIMBER TRUSS FOR FIVE METRES SPAN

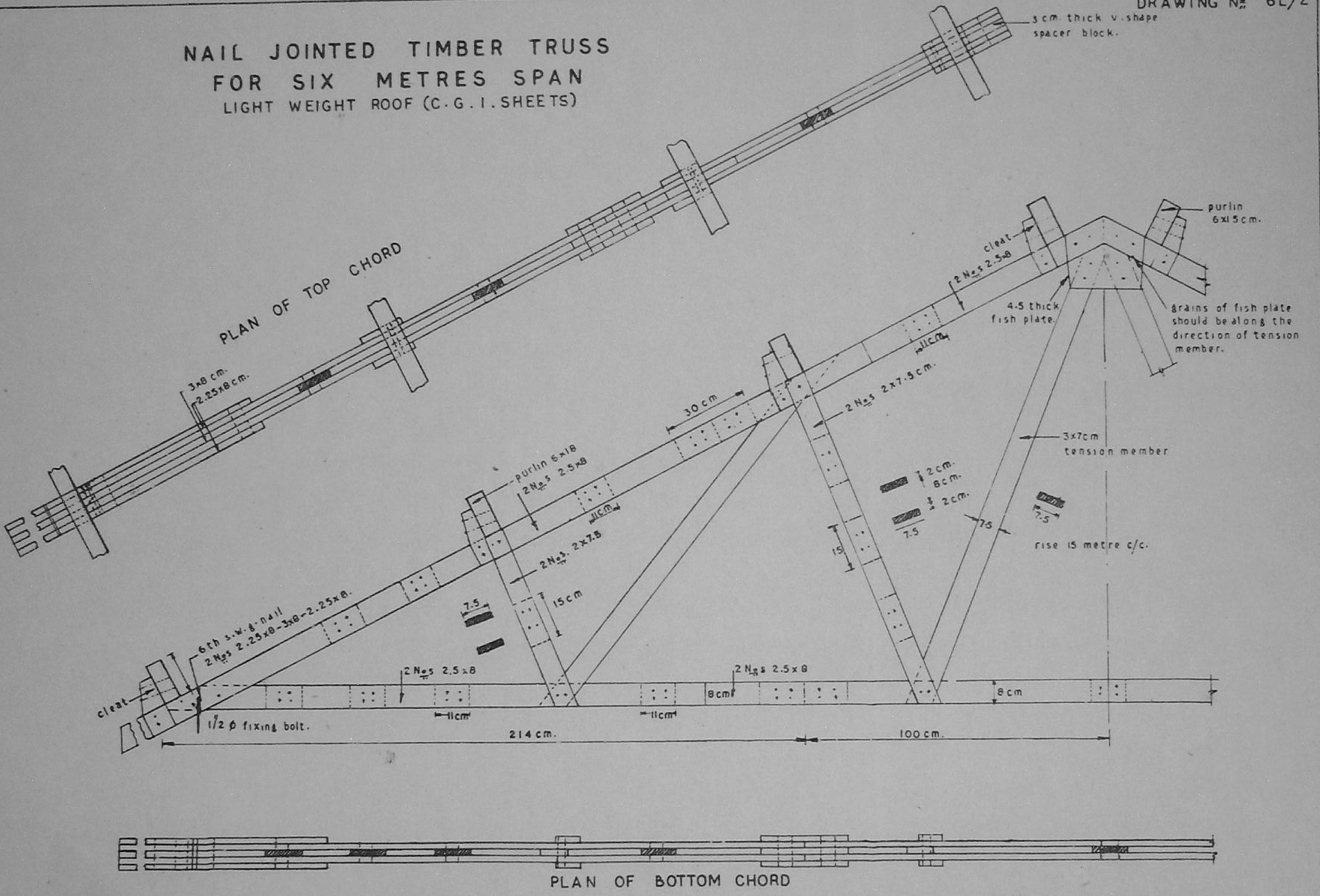
HEAVY WEIGHT ROOF (MANGLORE TILES)



DRAWING No. 6L/2

NAIL JOINTED TIMBER TRUSS FOR SIX METRES SPAN

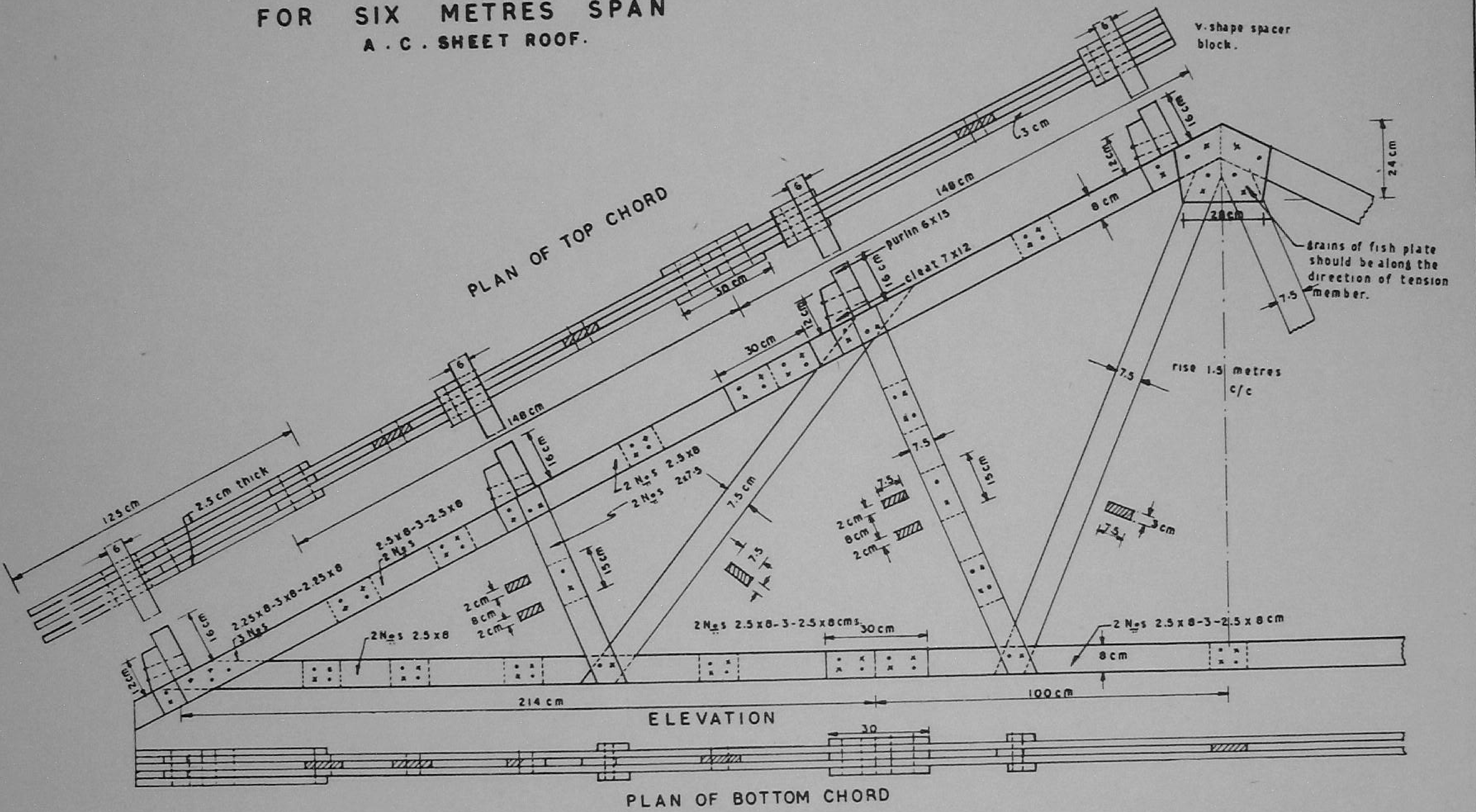
LIGHT WEIGHT ROOF (C.G.I. SHEETS)



DRAWING № 6 M/I

NAIL JOINTED TIMBER TRUSS FOR SIX METRES SPAN

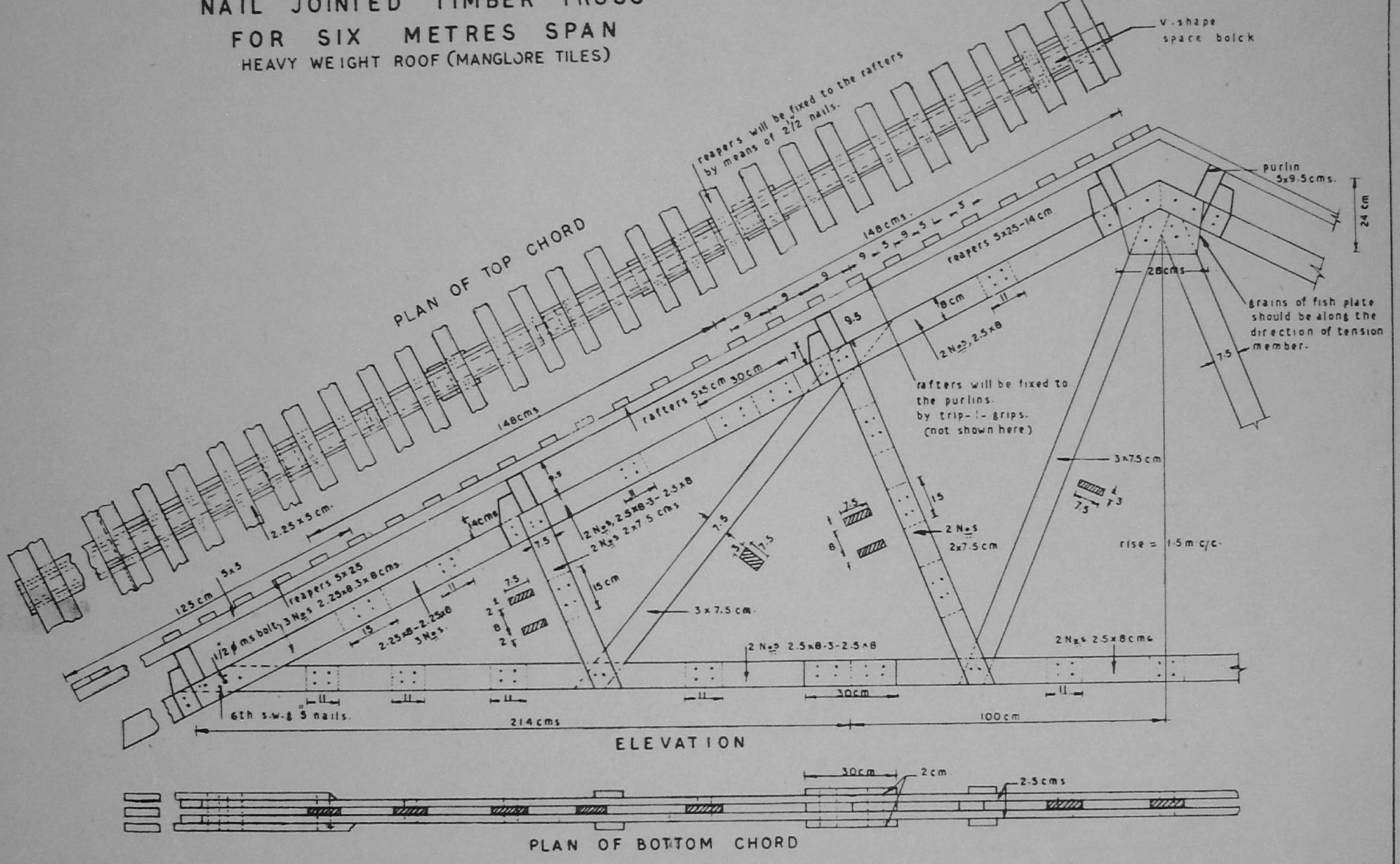
A . C . SHEET ROOF.



DRAWING No. 6H/2

NAIL JOINTED TIMBER TRUSS FOR SIX METRES SPAN

HEAVY WEIGHT ROOF (MANGLORE TILES)



11 Building Regulations For Rural Areas

11.1 General

11.1.1 The unsatisfactory housing conditions prevailing in most of the villages in the country could perhaps be ascribed mainly to the lack of any machinery to regulate house building activity in the villages. In a number of villages construction work is still going on in an irregular pattern without reference to any layout, standards or plans. Such construction in course of time will nullify the effect of Village Housing Project Scheme in the villages. Therefore, there is an urgent need to regulate building activity in rural areas.

11.1.2 However, one thing has to be clearly understood. In rural areas, people are mostly illiterate and technical facilities are either totally lacking or available on an extremely meagre scale. Under these circumstances formation of elaborate bye-laws is of no use as they will not be susceptible of implementation. What is needed is to formulate a set of very simple rules and regulations for regulating building activity in the villages. These rules should be easily understood by the villagers and it should be possible to implement them with the limited technical assistance available from the technical staff of the Block. These rules also cannot be enforced fully. Minor departures will have to be tolerated.

11.2 Administrative Machinery and Implementation of the Rules

11.2.1 The rules will be enforced by the Village Panchayat or Panchayat Union Council with technical assistance from the technical staff of the block.

11.2.2 Where the Master Plan of a village has been prepared by the Rural Housing Wing or the Rural Housing Cell, the houses shall be built within the frame work of such a Master Plan.

11.2.3 No person shall erect any building or alter or add to any existing building without written permission of the Panchayat. Intending builders shall put up an application accompanied by the following:

1. A site plan showing the location of the plot.

2. A line plan of the house showing arrangement and dimensions of various rooms, kitchen, bathroom, latrine, cattle shed, etc.

3. The following information should be given on the plan:

   (i) Height of plinth
   (ii) Depth of foundations
   (iii) Thickness of walls
   (iv) Height of roof
   (v) Sizes of doors, windows and ventilators
   (vi) General specifications (if possible).

11.3 The Rules

11.3.1 Every residential building shall provide for the following basic requirements:

1. One living room-cum-bed room.
2. A separate kitchen or a kitchen-cum-verandah.
3. A verandah.
4. A bathing enclosure with pucca floor.

11.3.2 *Density of Houses*—25 to 38 per hectare.

11.3.3 *Road Width*—7·5 m or more, if possible on new sites and 4·5 m or more on existing built-up sites.

11.3.4 *Size of Plot* —140 sq m (minimum). Minimum width to be 9 m.

11.3.5 *Covered Area*—50 per cent for plots up to 360 sq m. For plots exceeding 360 sq m, 50 per cent for the first 360 sq m and $33\frac{1}{3}\%$ for the remaining area.

11.3.6 *Plinth Height*

(i) 30 cm for the main house generally.
(ii) 45 cm for the main house when drainage is very poor.
(iii) 15 cm for cattle shed.

11.3.7 *Set Backs*—3 m for front. 1·5 m for the side for plots up to 160 sy m and 2·4 m for plots exceeding 160 sq. m.

11.3.8 *Height of Floor*—2·75 m clear for flat roofs, 2·25 m for sloping roofs at the lowest point.

11.3.9 *Room Sizes*

(i) 11 sq m for single room tenements.
(ii) 9 sq m for two room tenements.
(iii) Minimum width—2·5 m.

11.3.10 *Kitchen Size*—4·5 sq m. Minimum width 1·8 m.

11.3.11 *Bath Size*—1.8 sq. m.

11.3.12 *Ventilation Area*—8 per cent of floor area. To be increased to 10 per cent in case of humid climate.

11.3.13 *Distance of Cattle Shed and Latrine from Habitable Portion*—4·5 to 6 m.

11.3.14 *Latrine*—Sanitary type. Minimum area 1·1 sq m. Minimum width 90 cm.

11.3.15 *Water Supply*—Individual wells to be at a distance of 7·5 m from a soakage pit. Community wells to be at a distance of 30 m from any soakage pit, etc.

11.3.16 *Disposal of Sullage Water*—To be disposed into a soakage pit or kitchen garden.

11.3.17 *Size of Door*—Clear height 1·8 m. Clear width 75 cm.

12

Rural Water Supply

12.1 Introduction

12.1.1 The provision of safe and adequate water supply is of prime necessity for healthful living. It is difficult to imagine any clean and sanitary environment without water. Invariably the progress of sanitation throughout the world has been closely associated with the availability of water.

12.1.2 It is a known fact that in India the high incidence of guinea worm and the enteric diseases, such as cholera, typhoid and dysentry is mainly due to the use of "unprotected" water supplies in rural areas. These diseases are preventable provided water supplies are protected from contamination. Thus, the provision of protected and safe water is of vital importance in a programme of promotion of public health in rural areas.

12.1.3 The objectives of rural water supply are:

(a) To supply safe and wholesome water.

(b) To supply water in adequate quantity.

(c) To make water readily available to the users in order to encourage personal and household hygiene.

12.2 Progress of Rural Water Supply in India

12.2.1 Before the advent of the National Five Year Plans in 1951, activities in the country in the field of rural water supply were spasmodic and the progress haphazard. The State governments were unable to cope with the problem which had suffered continued neglect through centuries.

In the initial stages of the First Five Year Plan (1951-56) provision for water supply schemes in the States was made from the fund under Community Development Works and Local Development Works included in the Plan.

In 1954 the Union Health Ministry announced their National Water Supply and Sanitation Programme as part of the Health Schemes under the Plan, and made specific provisions to assist the States in the implementation of their rural water supply and sanitation schemes. Approved rural schemes, limited to population units not exceeding 5000, would be given a 50 per cent grant-in-aid by the Centre, the other 50 per cent being found by the State Governments, partly as grant-in-aid and partly as contributions from the villagers either in cash or in labour or in materials.

Only piped supplies to a group of villages from a single or multiple sources was envisaged under this programme. In the initial stages, however, piped supplies for individual villages were also included for implementation. Rural water supplies of the simpler types were all to be pursued under other programmes in the Plan administered by other Ministries.

12.2.2 To sum up, the rural water supply schemes in Five Year Plans have been dealt under the following 4 programmes:

(a) **The Natioal Water Supply & Sanitation Programme,** under the Health Ministry, included the more complicated types of rural water supply schemes involving engineering skill, pumping machinery and pipe work. 50 per cent of the cost of approved schemes under the programme was given as grant-in-aid by the Central Government, the remaining 50 per cent being found partly as subsidy by the State Government and partly as contribution by the villagers benefited.

(b) **The Community Development Programme** included the simpler rural water supply works taken up in the blocks, a specific provision being made therefor in the Block Development plans supplemented by local contribution.

(c) **The local Development Works Programme** administered by the Planning Commission and Finance Ministry expended a part of its allotted moneys on rural water supply operating outside the C.D. Blocks.

(d) **The Programme for the Welfare of Backward Classes** provided water supply facilities to scheduled castes, scheduled tribes and ex-criminal tribes operating specially in areas where these groups are concentrated.

12.2.3 *Progress Made*—The following will indicate the progress made under these different programmes:

NWSS Programme		C. D. Programme		L. D. Works		Welfare of B.C. Programme	
Expenditure incurred	Physical achievement	Expenditure incurred	Physical achievement	Expenditure incurred	Physical achievement	Expenditure incurred	Physical achievement
I Plan Rs. 5·6 crores	About 15,000 villages under both plans	Rs. 4·5 crores	1,07,000 wells (old & new)	Rs. 7·25 crores	29,650 wells (old & new)	..	..
		Rs. 11·5 crores	453,000 wells	Rs. 13 crores	1,02,050 wells	Rs. 3 crores	20,000 wells (new & old)
II Plan Rs. 18 crores							
III Plan Rs. 16 crores		Rs. 13 crores		Rs. 35 crores		Rs. 3 crores	

12.2.4 *An Evaluation of the Work*—It is estimated that roughly 15 million rural people would have been benefited under the National Water Supply and Sanitation Programme during the first two Plans, covering some 14,000 villages.

Under the other programmes, there is no definite data available regarding the number of villages and the population covered, apart from the total number of new and renovated wells dealt with.

12.3 Requirement of Water

12.3.1 Normally rural water supply schemes are designed on the basis of 45 litres of water per capita per day. In places where cost of drilling wells in difficult terrain is high and available sources are not plenty, the per capita consumption may be restricted to 25 litres. It may be pointed out that in a rural scheme where the consumers are expected to draw all their requirements from a public well or from street standposts and convey the supply to their homes it may not be practicable to assume that each family would draw and convey a 45 litre supply for the entire household. If a 45 litre supply has been assumed in a design for such schemes, it can obtain in practice only if facilities are provided at public stand-posts for subsidiary local use of the water. This, however, is not a sound practice. It is desirable, therefore, that the supply in such cases is limited to 25 litres where high local costs and limitations of source dictate such a step.

Some quarters advocate the inclusion of cattle with the rural population in the design of rural water supply schemes. The source could no doubt be designed to include the quantity needed for the cattle population wherever it is feasible and when the source is located near the community, in the shape of impounded lakes, conserved tanks, wells and the like. But it is extravagant to design the treatment plant, conveyance and distribution systems so as to provide also for the cattle population. Conveyance of a piped supply protected water from a distant source may cost as much as Rupees 50 and more per capita of the rural human population. To invest a like amount per head of cattle through a subsidy from the State and Central Governments is not a practical proposition. Local unprotected sources should be made to serve such needs. Here again, exceptions may have to be made in special cases, where local sources are not available for men or cattle and where the population may not care to stay in the village and utilise the scheme unless it met the water scarcity for the cattle as well. Such special cases may have to be dealt with on their merits, depending on the special local conditions.

12.3.2 *Population Growth*—Even after the population of a village has been determined, it is difficult to forecast its rate of growth. Much depends on future economic developments which may affect the village itself or the surrounding area. There is no agreement among designers as to what should be a suitable period of design for rural areas. On the basis of available data a 50 per cent increase in population would appear to be the minimum figure upon which any rural water supply design should be based, irrespective of the period of design adopted.

12.4 Standards of Purity of Drinking Water

12.4.1 The Committee on Public Health Engineering Manual and Code of Practice, constituted by the Ministry of Health, Government of India, have laid down the following standards of purity for drinking water.

In the following table, the limits designated under "permissive" apply to water that would generally be acceptable to the consumers; figures in excess of the "permissive" while not acceptable may still be tolerated in the absence of alternative and better sources, but up to the limits designated under "excessive", above which the supply will not normally be acceptable.

TABLE I

PHYSICAL AND CHEMICAL STANDARDS

Characteristics	Recommendations of the Committee	
	Permissive	Excessive
Turbidity (mg/l on silica scale)	5	25
Colour (units on Platinum-Cobalt scale)	5	25
Taste and odour . . .	Nothing disagreeable	
PH	7·8 to 8·5	6·5 to 9·2
Total solids (mg/l) . . .	500	1500
Total hardness as Caco3 (mg/l)	300	600
Calcium as Ca (mg/l) . .	75	200
Magnesium as Mg (mg/l) .	50	150
Iron as Fe (mg/l) . . .	0·3	1·0
Manganese as Mn (mg/l). .	0·1	0·5
Copper as Cu (mg/l) .	1·0	3·0
Zinc as Zn (mg/l) . . .	5·0	15·0
Chlorides as Cl (mg/l) . .	250	1000
Sulphates as SO 4 (mg/l) .	250	400
Magnesium and Sodium Sulphate (mg/l)	..	..
Phenolic substances as Phenol (mg/l)	0·001	0·002
Fluorides as F (mg/l) . .	1·0	2·0
Nitrates as NO3 (mg/l) . .	20	50
Alkyl Benzene Sulphonate (mg/l)	..	..
Carbon chloroform Extract (mg/l)	..	..
Arsenic as As (mg/l) . .	..	0·2
Barium as Ba (mg/l) . .	..	..
Cadmium as Cd (mg/l) . .	..	..
Chromium as hexa-valent Cr . (mg/l)	..	0·01
Cyanides as CN (mg/l) . .	..	0·01
Lead as Pb (mg/l) . . .	..	0·1
Selenium as Se (mg/l) . .	..	0·05
Silver as Ag (mg/l) . .	..	..

12.4.2 *Bacteriological Quality (Treated Water)*—The MPN index of coliform bacteria should be zero or less than 1·0. None of the samples should contain an MPN of coliform exceeding 10 per 100 ml.

Occasionally, the samples may show an MPN index up to 8 to 10 per 100 ml provided this does not occur in consecutive samples.

When consecutive samples show an MPN index exceeding 8 per 100ml, additional samples should be collected promptly from the sampling point and examined without delay. This should be done daily until samples collected on two successive days show an MPN index below 9 per 100 ml. If necessary, samples should also be taken from several other points, such as the service reservoirs, distribution system, pumping stations and treatment plant and examined for coliforms.

In addition, the operation of all treatment processes should be checked and remedial measures taken if necessary.

When the results obtained over a period of a month are considered, not more than 10 per cent of the samples examined in that period should have shown an MPN index of coliforms greater than 1 per 100ml.

12.5 Sources of Supply

12.5.1 From times immemorial communities have grown up only near sources of water. These sources should be exploited to the maximum possible extent. The existing sources of water in our villages are usually one or more of the following:

(a) Dug Wells

(b) Rivers or canals

(c) Ponds or tanks

(d) Springs

12.5.2 Dug wells are in use as sources of supply throughout India. But for the unfortunate fact that such wells are seldom properly protected from underground and surface contamination, they can be considered as excellent sources when the water table is high and deleterious salts are absent in the aquifers. Perennial rivers and canals are also good sources of supply if the water is not polluted in the vicinity upstream. Ponds and tanks though subject to all the possible dangers of pollution, are almost the major sources of drinking water in the dry regions of many southern states like Madras. Conditions favourable for spring sources exist only in a few localities, but with a little effort and expenditure these can be converted into excellent and sure sources of good drinking water.

12.5.3 *Selection and Development of Sources*—Before the final selection of a source of supply, a thorough investigation should be made of all the existing sources to find out the quantity of the supply, the quality of the water, and the economics involved in the development of the source and in the treatment of the water.

When underground water supply is available, and the supply is reliable both as to quality and quantity, this source should be preferred to surface sources, as the devlopment and maintenance of under ground sources and the treatment of the water from such sources is relatively simpler and more economical. Among surface sources rivers and canals with flowing water should be given preference over ponds and tanks with stagnant water, because the former categories of sources, even when polluted at certain places, possess self purification properties. Ponds and tanks should be selected as sources of supply only as a last resort, as keeping these sources and their catchment areas free from contamination is very difficult in practice. These factors are considered in some detail in the following paragraphs.

12.5.4 *Existing Sources*

12.5.4.1 *Dug wells*—By far, these are the most common sources of water supply for farms and rural homes. Though driven wells, bored wells, and drilled wells can be developed, dug wells are the oldest type and exist in all parts of this country. When properly located, constructed and protected, dug wells are more satisfactory than any other type, except drilled wells. They have a long life and a large volume, and permit of lower lifts and rapid pumping. They are also easily inspected and cleaned.

Several wells may have to be selected in a village for the purpose of developing them and utilising their water for drinking. In selecting the wells it should be ensured that they are at least 15 m away from sources of pollution. The required number of such wells are easily selected in many villages. and they need only developments in the form of cleaning and enclosing, to protect the water from pollution. Mostly the wells may be either unlined or walled with dry packed masonry all the way up. Sometimes the wells have steps leading up to the water. Often there is no parapet wall round the well. The water is usually lifted with buckets and ropes. Owing to the porous nature of the lining, the easy and direct access to the water or the indiscriminate use of all types of uncleaned vessels. and the absence of a parapet wall or a cover, chances of contamination of the well water are great.

The first step in the development of such existing wells is to ensure that the supply is adequate and safe, as otherwise no benefit will be derived by developing them. Wells which have the reputation of not drying up when bailed by hand may go dry when pumped with modern equipment. A pumping test should always be carried out in the driest part of the year to determine the yield. If there is any evidence of accumulation of sediment at the bottom of the well, it should be cleaned before the pumping test. When it is ensured from the pumping test that the supply is adequate to meet the demands of the community which will use the well, the next step is to get the water tested for biological, physical and chemical qualities in the nearest laboratory. For this purpose samples of water should be collected, packed and despatched for the test strictly according to the instructions.

The reconstruction should include the following usual provisions:

(a) At least the upper 3 m of the well should be made water-tight for ensuring safety against surface pollution. For this purpose the well is provided with a sufficiently thick lining of stone or brick masonry in cement mortar, or if possible a concrete lining to this depth. The masonry lining should be provided with outside plaster and a thick coat of tar should be given on the plastered surface. It will be better to have a puddle clay filling all round this lined portion. The rest of the well depth may be provided with a porous lining.

(b) A parapet wall at least 1 m high in stone or brick masonry, in lime or cement mortar. should be constructed around the opening of the well, and the top of the walling should be provided with a cover made of properly jointed wooden planks. Alternatively, the well can be covered 30 cm above the ground level with an R.C.C. cover extending 30 cm or more beyond the well curbing. The cover should be water-tight, and if heavy, should have a manhole with a tightfitting cover.

(c) A sloping impervious apron at least 1·8 m wide leading to a pucca 15 cm half-round drain should be provided all round the well. This apron can be of stone slabs jointed with cement mortar. If a brick masonry apron is provided, it should be plastered on top.

(d) If tanks are required for supplying water for washing clothes or for watering cattle, these may be provided as shown in Fig. 1.

(e) The waste water collected by the drain should be drained into a soak pit or vegetable garden, at least 15 m away.

(f) An area round the well having a radius at least equal to the depth of the well, should be reserved as protected area and fenced round to keep away stray cattle.

The above provisions are illustrated in Fig. 1.

When the reconstruction work is over, the well should be emptied and thoroughly cleaned. Then the well should be disinfected as described below:

Disinfecting Wells—This is done by chlorination using bleaching powder. The dose for chlorination is prepared by dissolving one heaped tablespoonful approximately 15 grams of bleaching powder of 25 per cent strength in 10 litres of water. One part of the dose should be added to 100 parts of the well water the total quantity of which should be calculated first. The curbing of the well should be washed down with the treated water. Then the well should be pumped dry, the curbing rinsed from top to bottom, and the rinse water removed. The well

should then be allowed to fill and the water should be pumped out rapidly. The rinsing, filling and pumping should be repeated twice or thrice. After this, the well may be put to use.

The unlined 'katcha' wells can be made sanitary by deepening the bottom, installing the hand pump with screen, filling the hole with coarse sand up to the water level and with the clay above that level. When material used for filling is completely consolidated, the platform and drainage have to be constructed.

12.5.4.2 *Rivers or canals*—Though it is well known that all surface water is open to the dangers of pollution, rivers and in some cases canals, are the only sources of drinking water in many villages. If there is a perennial flow of a copious supply of water in such sources, it is always possible with a little effort to ensure that the community gets water of the required standards from these.

When a river or a canal is the source of supply in a village, the length of the river or canal inside the village should be zoned off and any one zone should be used only for the particular purpose for which it is meant. The first zone should be used for supplying drinking water, the second for bathing, the third for washing clothes, the fourth for watering cattle, and the last for washing cattle. It should also be ensured that any drainage from the village is let into the river only after the river leaves the village. The river or canal should not be polluted at least in a distance of 1·5 km upstream of the commencement of the village.

12.5.4.3 *Ponds or tanks*—In areas where rainfall is scanty and the underground water is high in mineral contents, ponds and tanks are the only sources of drinking water. Some advocate the closing of such sources on account of the difficulty of keeping them unpolluted. But it is not practically possible to do so in many villages where people prefer to drink the water from such sources rather than the water from wells, which has a large quantity of dissolved salts. For example, this is the case in many villages in the Ramnad district of Madras State. However, in most of these villages there is an arrangement for strict watch and ward of such sources against pollution, and usually all sources of water are distinctly classified and maintained as sources of drinking water or as sources of water for bathing and washing. Under such conditions, it is always better to follow the traditional arrangement and try to develop one or more of the existing ponds or tanks as sources of drinking water rather than try to impose on the community the drinking of well water, which may not be sufficiently soft.

When developing ponds or tanks, not only the source proper, but the catchment area of the source and any channels carrying water to the ponds should be protected from pollution. The villagers should be informed of the necessity for keeping the catchment areas unpolluted and as a further precautionary measure, the catchment area should be fenced around with some sort of cheap local fencing material. Ponds should always be provided with sufficiently high bunds to exclude polluted surface water. The bunds should be free of vegetation that might harbour vermin. Tanks should have surplussing arrangements and all ponds should be provided with controllable inlets.

12.5.4.4 *Springs*—Where conditions exist such that the water table or a water-bearing strata is exposed by the action of a stream, water seeps out in the form of a spring. Springs are also formed by the seepage of water through fissured rocks. Springs of the later category exist in many hilly tracts in India. A good spring is usually a dependable and safe source of water.

Before developing a spring, the dry weather flow should be tested to find whether the supply is adequate. The quality of the water should be got tested. If the location of the spring is favourable for natural gravity flow, it is an additional advantage which should be taken into account. If the spring is found to be suitable from these considerations, protection works should be carried out to prevent pollution from surface water, cattle, sewage, etc. Usually this will involve benching above the spring to exclude surface water and fencing around to keep away cattle. The development of a spring is illustrated in Fig. 2.

12.5.5 *New sources*

12.5.5.1 New sources should be thought of only when none of the existing sources is found to be suitable from the point of view of quantity, quality or both. In such cases it will be advisable to resort to the following:

(a) New dug wells,

(b) Driven wells,

(c) Tube wells.

12.5.5.2 *New dug wells*—The development of a new dug well involves considerable expense and should be given careful consideration. As for finding out a sure source of location for a well there is no definite and easy method. Usually a reasonably good forecast of results can be done at little expense by an examination of the existing wells in the vicinity. The diameter of the new well may vary between 1·8 and 3 metres. The protection works will be exactly the same as have been described for existing dug wells.

12.5.5.3 *Driven wells*—It is possible to develop driven wells in sandy areas where an abundant quantity of water is available in porous strata at shallow depths. Such wells are quite low in initial cost, and a number of them can be provided at the required localities. A hand pump is used for lifting water from such wells. A driven well with hand pump having a pedestal is illustrated in Fig. 3.

12.5.5.4 *Tube wells*—These have been developed with success in Uttar Pradesh, Bihar, Madhya Pradesh, Punjab and Maharashtra, especially for irrigation purposes. In the absence of other suitable sources of underground water, tube wells can be resorted to. As deep water-bearing strata are less liable to be contaminated, such wells, when cased into bed rock and correctly sealed at the top of any sandwiched impervious layer of rock, and at the surface, afford maximum protection against contamination. Tube wells are also less affected by droughts as the aquifers are more likely to be extensive in area. Such wells often penetrate more than one water-bearing stratum and therefore, may provide a stronger flow. However, water from such wells is likely to have a high concentration of minerals, and therefore, drilling for such wells should be taken up only in areas where tube wells supplying good water have been developed before. In areas where tube wells are considered for the first time, test wells should always be first installed with a view to checking up the yield and the quality of the water.

In developing tube wells, the utmost care should be given to the proper installation of casing, the use of proper screen in the correct position, and the adoption of the correct method of construction for the particular formation. The job of drilling such wells is of a highly technical nature, and should be undertaken by professionals having the necessary equipment and experience. But these factors may not present any difficulty when a number of drilling projects for several villages having similar stratigraphic conditions are taken up at a time.

12.5.6 *Infiltration Galleries*—Infiltration galleries are nothing more than horizontal wells which collect water over practically their entire lengths. Where the construction of such galleries is feasible, a good and wholesome supply of water may be obtained.

The gallery is a simple means of obtaining naturally filtered water, and, for this purpose, it should be located 15 m or more from the bank of the river or lake. It is

constructed by digging a trench into the water-bearing sand, then collecting the water in a perforated pipe or gallery (masonry-lined or unlined) which leads to a central casing from which the water is pumped out. The walls of infiltration galleries may also be built of porous concrete. The length of the trench depends upon the amount of water desired and size of the water bearing pocket.

Careful tests to measure capacity should be made before constructing a complete gallery. The best galleries collect water well below the ground water level, thus making it necessary to de-water the working trench. This usually requires cribbing and de-watering pumps and therefore, is more expensive than a simple bored or driven well. This system, however, offers better possibilities of obtaining large quantities of water if a suitable formation, such as a reasonably coarse sand, can be found.

12.5.7 *Number of Wells and Travel Distance*—It has been estimated that at least 1 well should be provided for 200 persons in a village.

In order that the water is used in adequate quantities the travel distance should be reasonable, say not more than 100 m.

It should be remembered that if the distance of a protected water supply is very great, people will be tempted to use closer, perhaps polluted water source and to neglect the use of safe water.

12.6 Devices for Lifting Water

12.6.1 When the wells are the sources of drinking water, the water is usually lifted by bucket and rope. In such cases, even if the quality of water from the well may be safe, there is constant risk of pollution of the supply from the users and the ropes and buckets which they use. It is, therefore, essential that a well is invariably covered over and provided with hand pumps to prevent contamination. The provision of hand pumps should, therefore, be regarded as an essential aspect of protected water supply in rural areas. The provision of hand pumps will have to go side by side with the education of the people in the use of hand pumps and in their proper maintenance. It will also be necessary to encourage the manufacture of cheap, foolproof and robust hand pumps for use in the village with standardized spare parts supplied at cheap rates.

Sturdy hand pumps have been evolved recently, which are also very cheap. A pump capable of lifting 2500 litres per hour through a head of 6 m and costing just Rs. 130 is stated to have been developed in Bihar. For deep wells, dug or drilled, centrifugal pumps should be installed. The benefits of electricity have reached many villages today, and under our ambitious plans for electrifying rural areas, electricity will be reaching many more villages in the near future. Centrifugal pump sets are being manufactured in almost all the States of India at competitive prices. Hence the installation of such pumps should present no difficulty. In many villages centrifugal pumps have already been installed in large numbers for agricultural purposes. Even at places where there is no electricity, ingenious methods have been developed for running centrifugal pumps using bullock-power in conjunction with suitable mechanical gear. Such pump sets have been evolved in Andhra Pradesh. It is said that at a cost of Rs. 1,300 to Rs. 1,800 a pump set to lift about 12,000 litres per hour through 12 m can be installed. Centrifugal pump sets with suitable suction hoses provided with strainers can also be conveniently used for lifting water from all kinds of surface sources.

12.6.2 *Windmills*—Energy which Nature has provided, such as the wind, should be taken advantage of whenever possible. In many countries, wind energy is used for pumping water for farms, homes and small communities. This method is excellent for obtaining a steady flow of water from a well at a very low cost.

For proper operation, the following are necessary:

(1) Winds of more than 8 km per hour during at least 60 per cent of the time;

(2) Easy availability of windmill equipment;

(3) Wells that can be pumped for many hours duration each day;

(4) Storage capacity of three days' supply (or more) to take advantage of long pumping periods and to provide for calm periods when there is no wind;

(5) Clear sweep of wind to the wind-mill. This can be obtained by the use of a tower to raise the windmill 4·5-6 m or more above the surrounding obstacles.

The size of windmills is usually expressed in terms of the diameters of their windwheels. Sizes of 1·5 m to 9 m may be obtained from manufacturers. An idea of the capacities of windmills may be gained from the following examples. A 3 m mill in combination with a reciprocating pump cylinder 7·5 cm in diameter will produce about 750 litres of water per hour with a wind velocity of 16 km per hour.

12.7 Treatment of Water

12.7.1 From considerations of economy, the water should be given only the minimum treatment depending upon its quality as found from careful laboratory examination. The construction of large treatment works is not a practical proposal for villages. Always a source requiring the minimum treatment should be selected and only simple methods of treatment should be adopted.

12.7.2 *Well Water*—In areas where the well water is derived from sandy strata free of mineral salts, its quality is usually reliable provided sufficient precautions are taken to prevent surface pollution. The natural filtration undergone by the water while travelling in such strata, especially in the case of deep wells, is a great advantage. Under such conditions the water has only to be treated to remove the bacterial load. The easiest and cheapest method of disinfection is chlorination with bleaching powder.

For chlorinating water supplies on a small scale as in the case of the rural areas, bleaching powder is the most suitable reagent to use. A solution of suitable concentration is prepared and administered to the water under treatment in the desired proportion. The solution is thoroughly mixed with water and allowed to remain in contact for at least half an hour before the water is consumed.

In small supplies the water is generally pumped from a well or from an infiltration gallary into an elevated storage tank and distributed for consumption. The most suitable arrangement, therefore, would be to administer the chlorine solution before the water enters the elevated tank, which would provide the desired contact period before consumption.

If the water is being pumped by means of a single pump (which is normally the case with rural water supplies), the rate of flow of water would be uniform and a simple apparatus in which the rate of discharge of solution is regulated manually would be quite suitable. Chlorine solution can be applied to the water through the suction pipe of the pump. A very simple apparatus for this purpose supplied by a Calcutta firm costs about Rs. 1100.

A sufficient dose should be given to the well water till there is enough residual chlorine appreciable to the taste. The residual chlorine should be 0·1 to 0·2 parts per million after 30 minutes of contact. A dependable and easy method for testing residual chlorine is to use the Orthotolidine Test of colour comparison. Chlorine test kits are available, and after a little instruction, tests for residual chlorine can be conducted by almost any one who can distinguish colours.

collected in an outlet chamber. Here a regulating arrange-

better to select other sources of supply. Though the process of water softening is simple enough in principle, especially with the use of zeolite minerals, cheap and easily operated zeolite filters, suitable for rural areas, are still to be devised.

12.7.3 *Water from Springs*—Water from such sources may usually require only disinfection. This is done in the sump where the spring water collects.

12.7.4 *Water from Rivers, Canals, Ponds and Tanks*—Such waters do not contain dissolved salts but are high in sediments and bacterial load. Therefore, the treatment has necessarily to include sedimentation, filtration and disinfection. These operations have been described in subsequent paragraphs.

12.8 Rural Water Supply Scheme from a Canal

12.8.1 In many rural areas where water is of brackish quality, water for drinking purposes is obtained from a nearby canal. In such a scheme the following structures have to be provided.

1. Storage-cum-Sedimentation Tank—The storage-*cum*-sedimentation tank should provide storage for 15 to 21 days supply of water depending upon the closure period of the canal. 25 per cent provision should be made for evaporation and percolation losses. These tanks are normally of rectangular shape, the depth varies from 3·5 to 4·5 metres. The capacity of the feeder channel should be such that the whole tank can be filled in seven days.

2. Suction Well—The internal diameter of the suction well should be 1·5 metres. It should be connected with the storage tank by a 150 mm diameter pipe.

3. High Level Tank—From the suction well the water should be pumped into the high level tank. The capacity of the tank should be 8 hours' water requirement.

4. Filter—From the high level tank the water is fed to the filter. In rural areas normally slow sand filters are used. These are water-tight shallow tanks about 2·5 m to 3·5 m deep with a bed of concrete sloping towards a central longitudinal drain. On the top of the underdrainage system is laid gravel of a total depth of 60 cm in 5 or 6 layers. The lowest layer consists of a size varying from 65 mm to 40 mm. The upper layers are of progressively smaller sizes, the topmost being of 6 to 3 mm.

5. Filter Sand—This should also be 60 cm to 90 cm layer of graded and washed sand of effective size of 0·3 to 0·35 mm and of uniformity coefficient of between 1·75 and 2·0. The finer the sand, the more free is the filtrate from bacteria, but the lower is the output.

6. Outlet—Water after passing through the filter is collected in an outlet chamber. Here a regulating arrangement with a float gauge, such as a telescopic pipe, or adjustable weir plate, is provided so that the discharge of about 100 litres per hour per square metre is kept constant by varying the filtration head. For a new or freshly cleaned filter, this is about 10 to 15 cm. But as the filter gets clogged, it is gradually increased by manual adjustment so as to keep the discharge uniform. Slow sand filters are worked under a maximum filtration head of 75 cm. But to ensure a safe water supply, it should be, as a rule, less than the depth of filtering sand, say 2/3 to 4/5 of its thickness.

When the filtration head exceeds the permissible value, the filter requires to be cleaned. This is done by scraping about 1·5 cm to 2·5 cm of sand from top. The surface is then raked or roughed. After this, water is admitted on the top of the filter, but the filtrate is run to waste for 24 to 36 hours.

The bacterial efficiency of slow sand filter is 98 per cent to 99 per cent. It is not suitable for water having turbidity above 50 p.p.m.

7. Clear Water Tank—Water from the filters is fed to the clear water tank where it is chlorinated. The capacity of the clear water tank is 8 hours' requirement of water.

8. Over Head Tank—The water from the clear water tank is pumped into the over head tank. The capacity of the over head tank depends upon a number of factors, such as variations between maximum and minimum demands, etc. The normal storage should be between 8 and 12 hours average demand.

12.9 Design of Distribution System

12.9.1 The supply main should be designed for 1½ times the average daily demand. The distribution pipes should be designed for 2 times the average daily demand.

12.9.2 The velocity of flow shall not be more than 1·8 m per second in main pipe and 0·9 m per second in the distribution pipe.

12.9.3 The design is based on Hazen Williams Formula with the value of $C=100$. The design is greatly simplified by the use of Nomogram given in Fig. 4. It is based on $C=100$. There are 4 factors required for a design, *viz.* Q=discharge, d=diameter of pipe, h head lost in friction, and v=velocity. Out of these if any two are known the remaining two can be found with the help of the nomogram.

Place a straight edge on two known points and read at the intersection of the straight edge with the vertical, the values of other two hydraulic elements.

12.9.4 The distribution system should be so designed that the residual head is at least 4·5 m.

TABLE 2

NUMBER OF CONNECTIONS FED FROM A MAIN

Diameter of Delivery Main	Diameter of Branch Pipe									
	100 mm	90 mm	80 mm	65 mm	50 mm	40 mm	32 mm	25 mm	20 mm	15 mm
	Number of Branch Connections									
100 mm .	1	1	2	3	6	10	17	32	53	113
90 mm .	..	1	1	2	4	8	13	25	43	88
80 mm .	..	..	1	2	3	6	10	18	32	66
65 mm .	..	..	..	1	2	3	6	11	19	39
50 mm .	..	..	..	..	1	2	3	6	10	20
40 mm .	..	..	..	..	..	1	2	3	6	12
32 mm .	..	..	..	..	..	..	1	2	3	7
25 mm .	..	..	..	..	..	..	..	1	2	4
20 mm .	..	..	..	..	..	..	..	..	1	2
15 mm .	..	..	..	..	..	..	..	..	..	1

12.10 Valves

12.10.1 *Sluice Valves*—These should be provided on the distribution system in such a manner that if any circuit is to be cut off for repairs, checking or other reasons, the general supply to the rest of the village is not affected.

12.10.2 *Air Valves*—Air valves should be provided on the summit points to guard against air locking.

12.10.3 *Scour Valves*—Scour valves should be provided at low point between the summits to facilitate scouring operations.

12.11 Distribution of Water

12.11.1 Due to lack of resources and poor economic conditions of the villagers it is not possible to provide individual connection to every house in the village. In the beginning a row of taps is provided near the overhead water tank from where the villagers can take water to their houses. As more funds become available, the supply mains are extended to the inner parts of the village gradually, till a net work of public water stand posts is available in the village so that no villager has to travel more than 100 m from his residence for bringing water from the public water tap. Individual connections are also given to some people who are economically better off. Normally one water tap is provided for 150 to 200 persons. The taps should be of self-closing type to avoid wastage of water. Proper arrangements for drainage of waste water should be provided. Washing platforms should also be provided near the stand posts.

12.12 Maintenance Charges

12.12.1 The village Panchayat pays for the cost of electricity and maintenance charges of the water supply scheme and collects it as a levy from the households. The amount varies from 50 paise to 75 paise per family per year.

12.13 Maintenance of Water Supply Scheme

12.13.1 The maintenance of completed schemes should receive special importance. Most often, it was neglected in the past as a result of which the villagers were helpless against inefficient operation and maintenance of a system or its breakdown in consequence. The administrative responsibility for the proper operation and maintenance of completed water works involving any kind of mechanical equipment like water treatment plant, pump-sets, chlorinating equipment, distribution reservoirs and a distribution system with appurtenances should be placed under the local Panchayat or Samiti with effective control being exercised at the district level. The technical responsibility for proper operation and maintenance should be ensured by the employment of minimum qualified technical staff either singly for any particular village system or jointly for several contiguous villages, so that proper operation and supervision thereof is ensured round the week. The district centre should have adequate spares for necessary materials and a mobile unit with a repair gang available to deal summarily with break-downs, repairs, renewals, etc.

12.14 Conclusion

12.14.1 In this chapter an attempt has been made to propose certain suggestions for adoption in designing, operating and maintaining village water supply schemes. The possible sources of supply in any particular village may be several. Every village has its own problems and limitations as regards the availability of funds, materials etc. In such circumstances no rigid solutions can be prescribed to overcome the particular situations. Only by a careful study of the local conditions it will be possible to select the most suitable and economic method of supply. However, it should always be remembered that local labour, local materials and local assistance should be utilized to the maximum extent. The main endeavour should be to improve the existing water supply system with an idea to make it safe and dependable. This will be the most fruitful method to convince the villagers of the genuine aims, and to secure their cooperation. The fact that the success or failure of a scheme depends largely on them needs no emphasis and is but too obvious.

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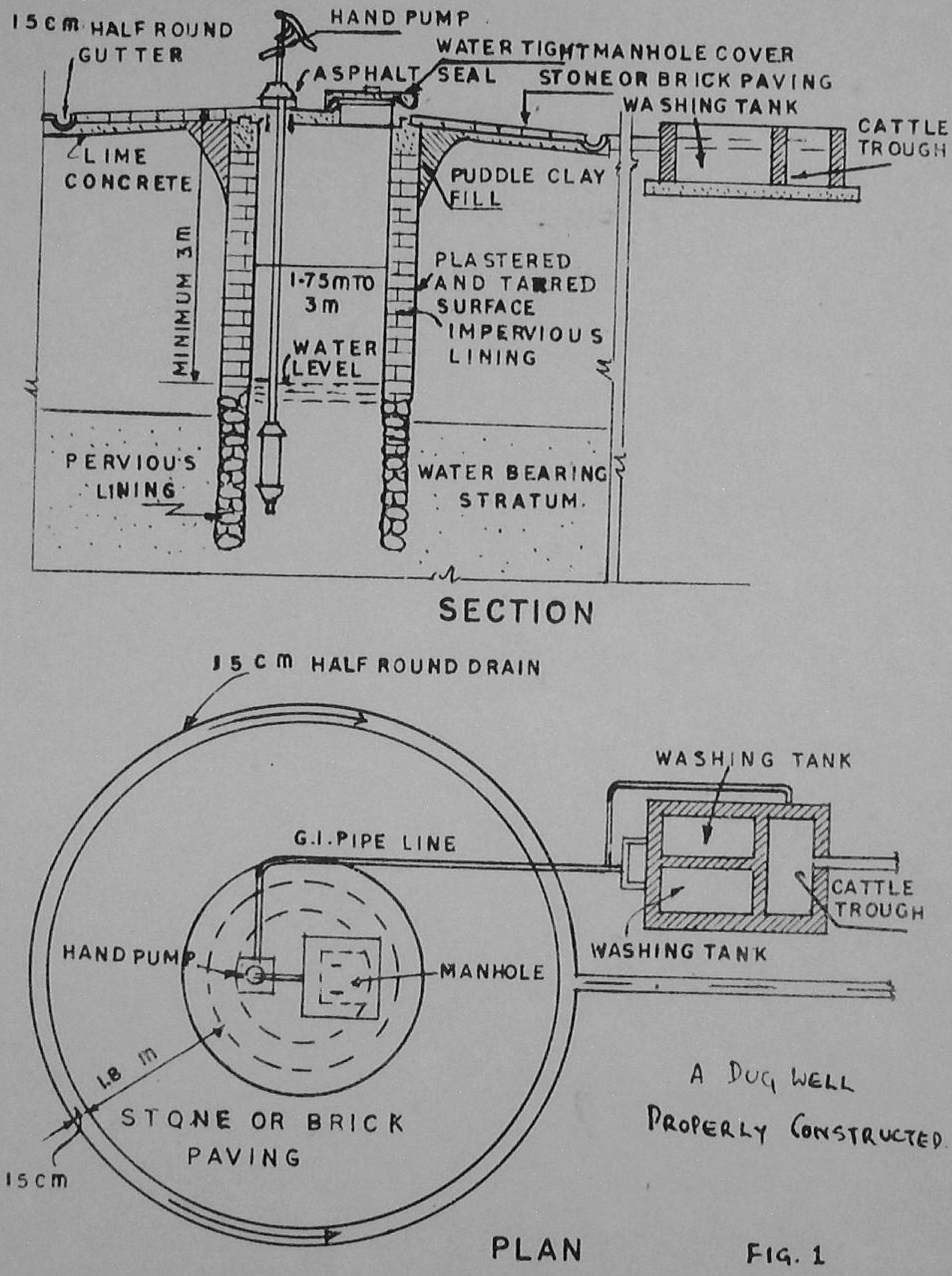

A Dug Well Properly Constructed

FIG. 1

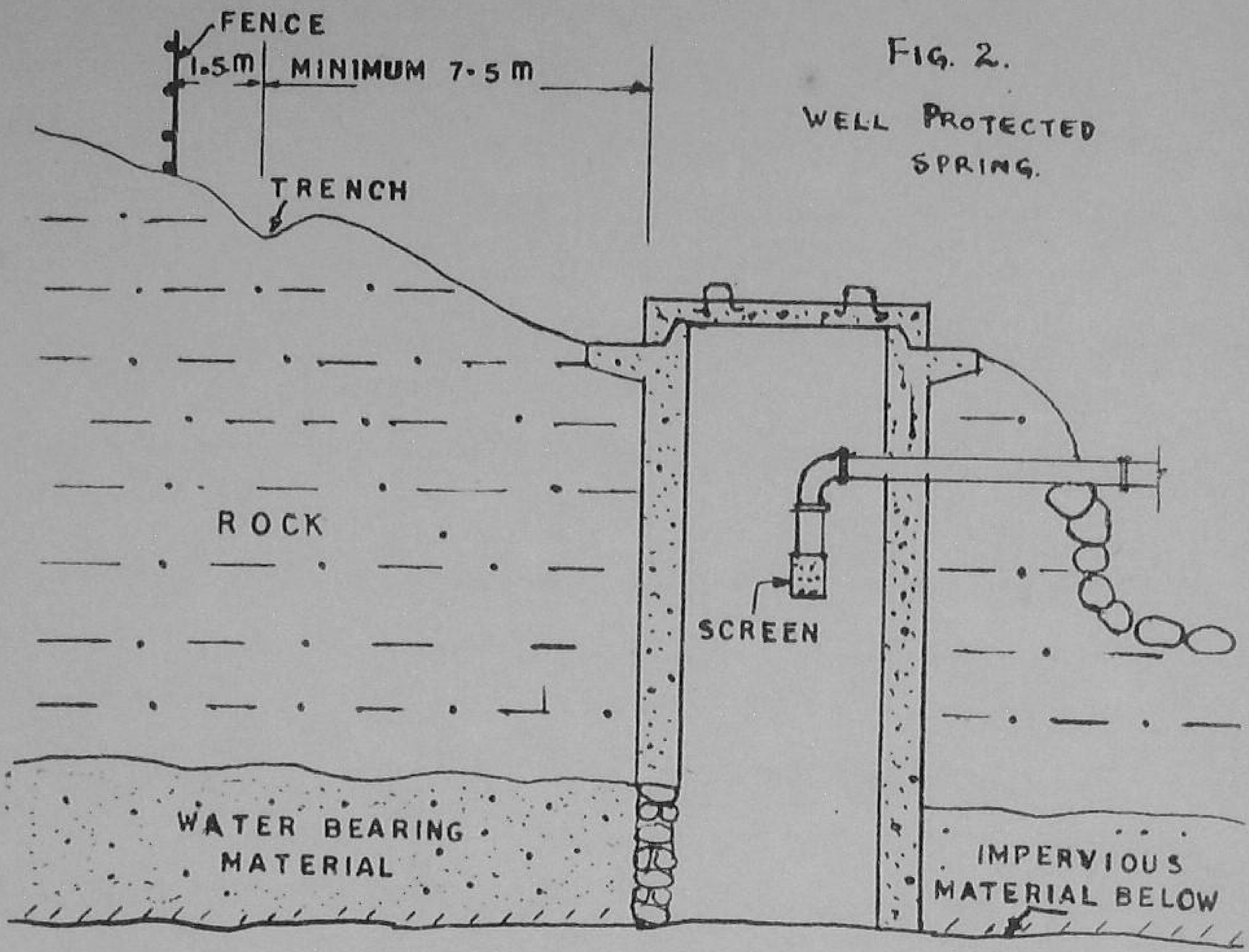

FIG. 2.

WELL PROTECTED SPRING.

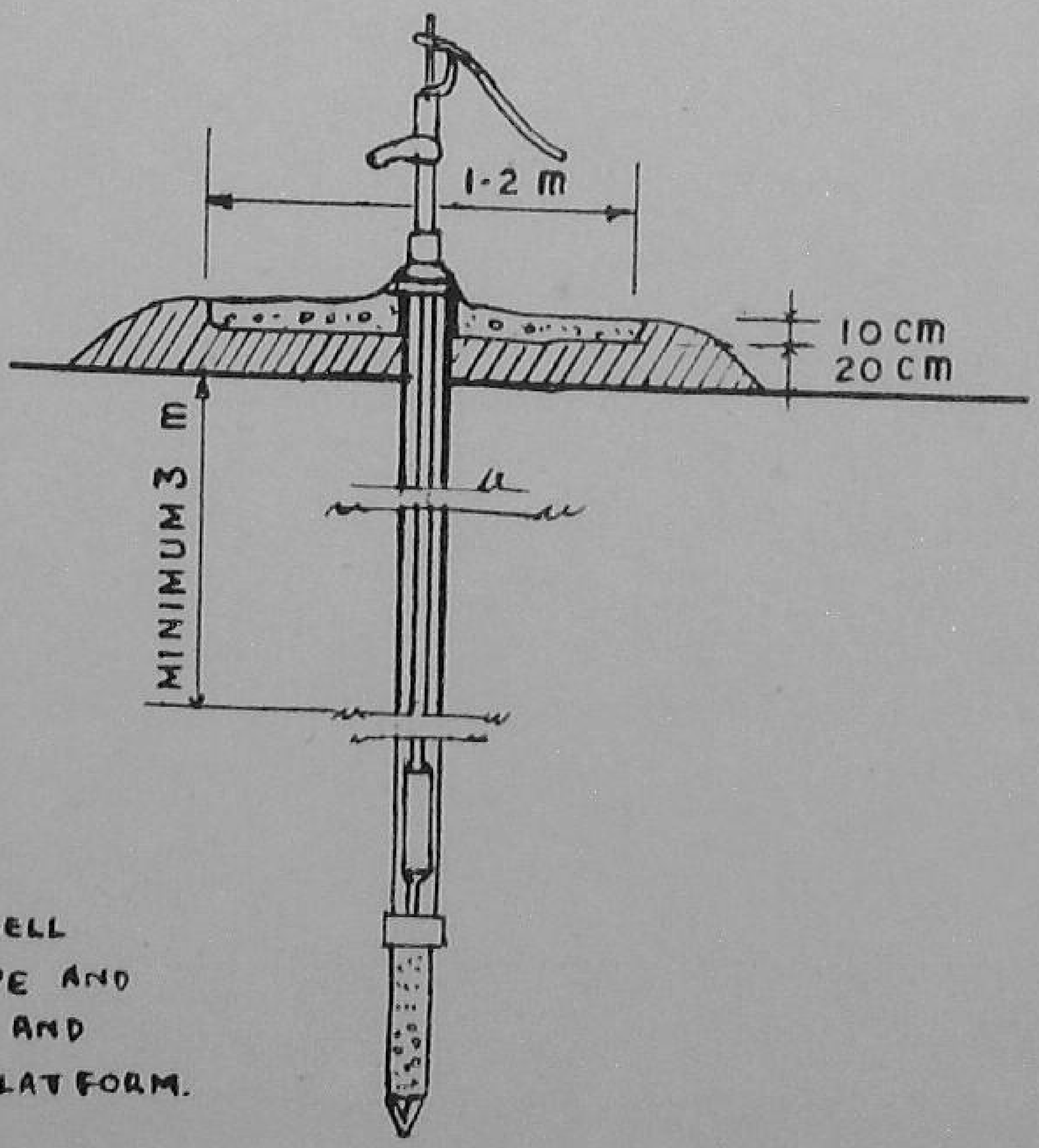

FIG. 3

DRIVEN WELL WITH DROP PIPE AND CYLINDER AND PROTECTIVE PLATFORM.

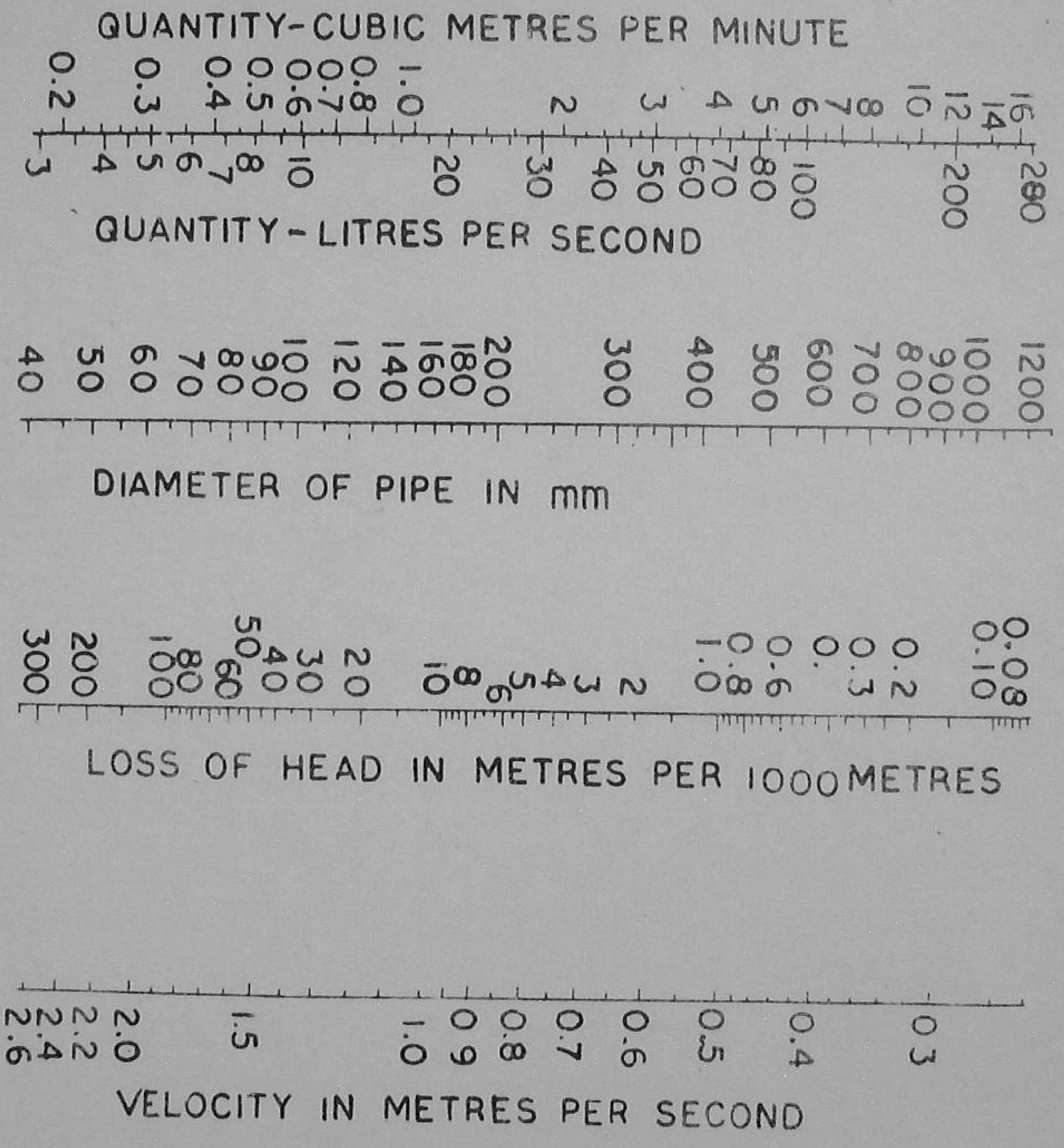

FIG. 4. NOMOGRAM FOR HAZEN WILLIAM FORMULA (C=100)

13 Rural Sanitation

13.1. Introduction

13.1.1 Environmental sanitation is very essential for healthful living. Environmental sanitation in rural areas should consist of proper disposal of human excreta without contaminating surface soil, surface water and ground water; disposal of sullage and storm water, animal dung and garbage; and provision of smokeless chulhas. This chapter deals with all these aspects of rural sanitation.

13·2 Sanitary Latrine

13.2.1 Proper disposal of human waste is an important part of environmental sanitation, since the intestinal infections common to man, are transmitted by faecal discharges of sick persons through carriers of disease. Improper waste disposal allows these discharges to be carried to the mouth of the next victim by way of flies, drinking water, food or soiled hands.

In India, now that incidence of malaria has been greatly reduced by control and eradication programmes, faecal-borne illnesses are the most formidable problems in the country. Intestinal infestation by worms is wide spread in the country, of which Hookworm is the most important. Though not a killing disease, its debilitating effects are a real drag on human health. The intestinal parasites offer a strong competition in the human body against metabolism of food. The economic loss from deaths occurring from faecal-borne diseases as well as from the illness with attendant disability and lowered productivity is indeed considerable.

To control these diseases it is only necessary to provide a barrier between the source of infection, the disease-producing organisms in infected excreta and the susceptible hosts—the human beings, by preventing faecal matter from coming into contact directly with men or with their food or drinking water. The most satisfactory method of excreta collection and disposal is the sanitary sewer and disposal system, but it is not possible to install such systems in our villages for many years to come. It is also not generally feasible to install individual septic tank with necessary plumbing and separate disposal. A sanitary latrine and a disposal pit are just as effective as these methods in controlling faecal borne diseases and are cheap to build and easy to maintain. This device is within the reach of our villagers. They cannot afford to be without such a latrine, since the cost of having one is far less than the cost of medical care otherwise necessary and loss of man power and human life due to faecal borne diseases.

13.2.2 A number of types of latrines have been developed in India by various organisations. The details of water-seal type sanitary latrines approved by the Central Public Health Engineering Organisation of the Ministry of Health, Government of India have been shown in Fig. 1. This is a very satisfactory type of latrine and requires about 2 litres of water for flushing.

In places where water is not used for ablution or is scarce, a cement concrete squat plate set over a deep pit or bore-hole is a satisfactory solution. The aperture in the squat plate should be kept covered. If people are reluctant to use any cover, the pit should not be used when the night soil reaches to within one metre of the ground level.

13.2.3 *Latrine Location*—Regarding the location of latrines with respect to sources of water supply, the following conclusions may be drawn from up to date information.

1. There can be no arbitrary rule governing the distance that is necessary for safety between a privy and a source of water supply. Many factors, such as slope and level of ground water and soil-permeability, affect the removal of bacteria in ground water. It is of the greatest importance to locate the privy or cesspool downhill, or at least on some level piece of land, and to avoid, if possible, placing it directly uphill from a well. Where uphill locations cannot be avoided, a distance of 15 m will prevent bacterial pollution of the well. Setting the privy off to either the right or the left would considerably lessen the possibility of contaminating the ground water reaching the well. In sandy soil a privy may be located as close as 7·5 m from a properly constructed household well, if it is impossible to place it at a greater distance. In the case of a higher-yielding well, not less than 15 m should separate the well from a latrine.

2. In homogeneous soils the chance of ground-water pollution is virtually nil if the bottom of a latrine is more than 1·5 m above the ground-water table. The same may be said if the bottom of a cesspool is more than 3 m above the level of the ground water.

3. A careful investigation should be made before building pit privies, bored-hole latrines, cesspools, and seepage pits in areas containing fissured rocks or limestone formations, since pollution may be carried directly through solution channels and without natural filtration to distant wells or other sources of drinking water supplies.

Regarding the location of latrines with respect to dwellings, experience shows that the distance between the two is an important consideration in the acceptability of the sanitary facilities. The location of latrines, private or communal, at a considerable distance or away and uphill from dwellings has been observed to mitigate against their regular use and proper maintenance. A latrine will more likely be kept clean if it is close to the house or other buildings which it serves.

4. Other considerations are as follows:

(a) The site should be dry, well drained, and above flood level.

(b) The immediate surroundings of the latrine—an area 2 m wide around the structure—should be cleared of all vegetation, wastes, and other debris. This recommendation may be ignored, lopment of rural areas where it is necessary, for example, in order to secure acceptability of the latrine by the local population, to avoid disturbing the natural bush-type surroundings which were previously used for defaecation.

13.2.4 *Details of Design*—The essential parts of this type of sanitary latrine are:

1. Pan
2. Trap
3. Lead off pipe
4. Plate or slab with foot rest
5. Pit or bore-hole

(*See* Fig. 1).

Pan—The length of the pan is 430 mm. The width of the front portion of the pan is 130 mm and the width at the widest part is 200 mm. The depth of the front portion of the pan should be at least 75 mm, so as to serve as urine splash guard. There is a uniform slope from front to

back at a 25 degree gradient. Lower pan opening should be 75 mm in diameter.

Trap—The trap can be 70 or 75 mm in diameter. However, upper opening of the trap which is connected with the pan should be 75 mm. Experience has shown that a trap having 75 mm diameter gives a high velocity flush with large masses of faecal matter, although in many cases a 70 mm trap will work satisfactorily. The recommended depth of water seal is 20 mm.

Lead off Pipe—The lead-off pipe is to be used when the squatting plate is set off from the pit or bore-hole. It should be 75 mm in diameter, with a bend at the end. The bend is to protect the wall from caving when a bore hole is used and is not necessary, if a large pit is used.

Pit or Borehole—A dug pit 750 mm in diameter or 750 mm square and 2000 to 3000 mm deep may be used. A bore hole of 400 mm diameter may also be used. But it is not so satisfactory owing to caving and rapid filling. Any pit or borehole will eventually fill up, and it will be necessary either to empty it or to cover it with earth and provide a new pit or borehole.

When the latrine plate is set directly over the pit or borehole, emptying the pit may be difficult. When the latrine superstructure is of a permanent type or when there is lack of space, moving the latrine, on to a new pit is also difficult. Under these circumstances, the pit or bore-hole is better located separately and behind the squatting plate and connected by 75 mm diameter lead-off pipe. This makes it easy to empty the pit, if desired, or to cover it when filled and dig a new pit nearby, without having to move the latrine.

When the faecal material is to be used as a fertilizer, it is necessary that a filled pit or borehole be covered and left for about a year before the material is taken out and utilized. While the first pit is filled and maturing, a second pit or bore-hole is necessary and the lead-off pipe should be switched to drain into the second pit. The minimum distance between the two pits should be 60 cm. In loose soil or in areas of high water table, a lining of earthen or cement concrete casing, or bamboo matting held in place by metal rings or planking, can be used to prevent caving of the pit or borehole. The pits can also be lined with soil cement mixture (containing 2·5 per cent cement).

The Slab or Squatting Plate—The slab is of cement concrete with minimum dimensions of 900 mm square, but it can be larger. It is 50 mm thick at the outer edge. There is 12 mm slope towards the pan, so that the slab is 38 mm thick at the pan opening in the centre. This slope is necessary to drain off all water from the plate into the pan. Where the plate is to be installed over a dug pit, minimum reinforcement may be used or the thickness may be increased to 75 mm at the outer edge and 63 mm at the pan opening in the centre.

The overall length of each footrest is 350 mm. The back edge of the foot rest extends to 75 mm beyond the outer rim of the pan, at its widest diameter. The inner edge of the foot rest continues forward along the rim of the pan to the narrowest diameter of the pan, and then angle off for a distance of 130 mm. The front edge of the foot rest is 145 mm wide and forms a right angle with the outer edge of the foot rest. The minimum height of the foot rest is 12 mm. This may be varied to suit individual fancy. The back portion is raised slightly (12 mm) so as to give a slope which makes for a more comfortable squatting position.

Superstructure—The nature of the structure varies according to the means of the family. An ordinary structure can be constructed with bamboo posts at four corners and with bamboo matting as walling, with a bamboo matting door in the front. Otherwise a more costly permanent structure can be built. The floor of the latrine should be such that it can be washed and kept clean. The clear height of the roof should be 2 metres. It is desirable to provide openings 10—15 cm wide at the top to facilitate ventilation.

13.2.5 *Construction Costs*—The cost of a cement concrete pan and trap is about Rs. 5.00. The cost of the cement slab or plate is another Rs. 5.00. A number of State Governments give subsidies to defray the cost of pan, trap and squatting plate.

13.2.6 *Construction*—The pan, the trap, the squat plate and the lead off pipes can be manufactured in a central place from where they can be supplied to a number of villages. Such an experiment has proved very successful in village Chinhat in U.P. where latrine pans, traps and other accessories are manufactured on a cooperative basis. Complete details regarding fabrication of moulds for the latrine parts have been given in the publication "Rural Latrine Programme", published by Directorate General of Health Services, Ministry of Health, Government of India, New Delhi.

13.2.7 *Directions for Use of Sanitary Latrines*

1. Disinfectants should not be used.
2. The pits should be inspected before and after rains.
3. There should be no water stagnation around the pit.
4. Only water should be used for ablution. Paper, cloth, rags, etc should not find their way into the latrine as they will choke the trap.
5. A little water should be spilt on the seat before squatting.
6. After use, it should be flushed with 2 litres of water.
7. A pot should be placed permanently in the latrine to provide a constant supply of flushing water.
8. Children should not be allowed to put stones, etc, in the trap, or to poke it with sticks.

13.2.8 *Educational Aspects of Sanitary Latrine*—Latrines are not readily accepted by the rural population because of their age-old habit of defaecating in the open field and lack of knowledge on the health hazards associated with defaecating in open fields. They have a poor image of the latrine. All these need a planned programme of health education as a pre-requisite to a programme of making latrines fully acceptable. Secondly construction of latrines is not an end in itself. Latrines need day to day and year to year maintenance. A system of follow-up is very essential in order that the villagers maintain their latrines properly and use them.

There are five important phases through which villagers pass before they really change their habits and use latrines:

1. Understanding what is a latrine.
2. Learning that a latrine can be clean and odourless and constructed cheaply.
3. Learning that a latrine is desirable in the house because it leads to health protection, convenience, privacy, safety, prestige and economy.
4. Deciding on type and location.
5. Developing habits of use and maintenance.

All these phases should be tackled through direct discussion, demonstration and audio-visual aids by the Block staff.

13.2.9 *Public Versus Individual Latrine*—Experience in all parts of the world indicates that except in unusual circumstances, multiple units should never be substituted for the individual family latrine. True, it is cheaper and less troublesome to construct a few communal latrines in a community than to build a large number of individual latrines at the rate of one unit per family. However, it has

been discovered after a few years use, these public latrines will be employed by only a portion of the population for which they are intended, the remaining reverting to original practise.

Public latrines, therefore, should be built only where absolutely necessary and should be designed to facilitate maintenance and constructed for permanence, as far as possible. They must be kept clean at all times, for, unless cleanliness is observed, they will not be used.

13.3 Septic Tank

13.3.1 The septic tank is the most useful and satisfactory unit for the disposal of excreta and other liquid wastes from individual dwellings, small groups of houses, or institutions located in rural areas.

13.3.2 *Working of a Septic Tank*—The functions of a septic tank are essentially:

(a) to settle the heavy settleable solids, and

(b) to bring about the maximum digestion of organic solid matter in the sewage.

Raw sewage from the toilet is admitted into the first chamber of the septic tank, which acts as a settling chamber where most of the settleable solids are deposited under the force of gravity. The sewage then enters the second chamber where millions of anaerobic micro-organisms attack and partially break it up into solids, liquids and gases. The complex and putrifying unstable organic compounds are broken in the tank and reduced to simpler, stable components, suitable for further treatment. The solids settle at the bottom of the tank as sludge and are removed periodically; the gas escapes through a vent and the liquid is further strained through a filter and discharged. As anaerobic bacteria cannot flourish in the presence of light and air, contact with air is prevented through the natural formation of a layer of scum on top of the liquid in the tank. The entry of sewage and the exit of the liquid has to be so arranged that movement is reduced to the minimum and no short-circuiting is possible in the liquid; otherwise, bacterial action suffers.

13.3.3 *Essential Parts of a Septic Tank*—Septic tanks are divided into two compartments—namely, the grit chamber, and the septic tank chamber. See Fig. 2.

(a) *Grit chamber*—Liquid from the toilet first enters this chamber. In order to prevent agitation of the contents in the tank, sewage is admitted into this compartment through a submerged inlet. Solid inorganic matter collects near the bottom of this chamber. An opening is provided in the partition between the grit chamber and the septic tank chambers, the height of the opening being governed by the depth to which the sludge is allowed to accumulate before removal.

(b) *Septic tank chamber*—The liquid flows into the chamber from the opening between the two chambers and the outlet is provided on the face opposite to the inlet end. Scum formed on top of the liquid in this chamber prevents the latter from coming in contact with air and thereby facilitates effective bacterial action. The sludge collected at the bottom is removed periodically. An asbestos cement vent pipe is provided in the roof to remove the gases that form due to anaerobic action.

Periodical cleaning, *i.e.* removal of digested sludge is essential as no septic tank can function eternally without the removal of sludge. The normal cleaning period is about six months to a year.

13.3.4 *Design of a Septic Tank*—The size of a septic tank is governed by the following factors:

(i) The floor area of the grit chamber has to be adequate to reduce the velocity of flow and to permit sedimentation.

(ii) Capacity should be adequate to provide a retention period varying from 12 hours to 3 days 24 hours period is usually considered satitsfactory.

(iii) The depth below partition opening has to be sufficient to permit sludge accumulation for a predetermined period. A minimum area of 700 cm^2 per user in the grit chamber and minimum volumetric content of the grit chamber of 20 litres per user are required.

(iv) A minimum capacity of the combined grit and septic tank chambers of 85 litres per user is required. For larger septic tanks per capita capacity may be slightly reduced. If the sludge is cleared at intervals of one year, a sludge accumulation capacity of 45 litres per user should be provided in the septic tank chamber.

13.3.5 *Suggested Internal Dimensions of Septic Tank*:

No. of Persons	Inside Dimensions		
	Length (m)	Breadth (m)	Height (m)
10	1·80	0·60	0·95
30	2·70	0·60	1·40
50	3·35	0·75	1·60
100	4·25	0·90	2·00

13.3.6 *Construction*—Septic tanks may be constructed out of brick-work, stone masonry, concrete or other suitable materials. Walls built out of brick should not be less than 20 cm thick and should be plastered to a minimum thickness of 12 mm inside and outside with cement mortar not weaker than 1:3; where they are built out of stone masonry, they should have a minimum thickness of 37 cm. The floor should be of cement concrete of proportion not less than 1:2:4 and should be sloped towards the sludge outlet, if any. Septic tanks may be built out of precast or cast *in-situ* concrete and should have a mix of proportion not leaner than 1:2:4. Every septic tank should be provided with ventilating pipe of at least 50 mm diameter. The top of pipe should be provided with a suitable cage of wire mesh. The ventilating pipe should extend to a height which would cause no smell nuisance to any building in the area. Generally the ventilating pipe may extend to a height of about 2 m when the septic tank is atleast 15 m away from the nearest building and to a height of 2 m above the top of the building when it is located closer than 15 metres.

13.3.7 *Disposal of Effluent*—When a stream with perennial flow is available, the effluent may be discharged into it provided the dilution is not below 300 volumes and water in the vicinity of the discharge point for a distance of 1·5 kilometre is not used for drinking purposes.

Where land is available and the soil suitable for absorption, the simplest method of disposal of effluent is to let it soak into the field through a system of underground open-jointed drains surrounded by loose material of gravel, cinder, crushed stone or brick bats, the tops of which should be covered with straw before being covered with soil. The diameter of the open-joined pipe should be 80 mm.

Normally a 1·50 m length of drain per user is considered adequate where the discharge from the tank consists of sewage from toilets only. For a large sized disposal field, the drains may be constructed in parallel rows, 3 m apart.

Where space is restricted, soak pits may be used, particularly in areas where rainfall is not heavy. Capacity of the soak pit should be about 150 litres per user, and it should be filled with brick bats or broken stone. Effluent from the septic tank is led into this soak pit and is gradually absorbed into the surrounding ground. No underground drinking water supply should be situated within a radius of at least 30 m from a disposal field or a soak pit.

13.4 Sanitation of Cattle Sheds and Disposal of Animal Dung.

13.4.1 In villages cattle sheds usually remain very dirty and create very insanitary conditions. The floor of the cattle shed should be constructed of soil-cement (containing 2·5 per cent cement) and 33 per cent brick ballast. The urine should be conveyed through a drain to a soakpit. The normal method of disposal of animal dung is to dry it in the form of cakes and burn them as fuel. This method is neither hygienic nor economical. The economic and hygienic method of animal dung disposal is to use it in a gobar gas plant or to compost it for manure.

13.5 Gobar Gas Plants

13.5.1 In rural areas disposal of animal dung poses a number of sanitation problems. The normal method of disposing animal dung is to dry it in the form of cakes which are burnt as fuel for domestic purposes. This not only leads to insanitary conditions in the house and around the village, but deprives the agricultural land of an excellent organic manure. Animal dung contains ingredients which could be exploited separately for their fuel and manurial values, but use of dung cakes as fuel not only fails to recover the full fuel value of the dung but also totally ignores its manurial value and allows that to be wasted.

13.5.2 Such a colossal waste of the manurial properties of animal dung can be avoided and a more economic utilisation of its fuel content can be achieved by adopting the simple technique of anaerobic fermentation of animal dung. During anaerobic fermentation, a gas is generated which can be easily collected and used as fuel. The residue left over from fermentation retains the manurial value of dung and in fact, it is better than the compost prepared by ordinary method. Gas generation from animal dung, therefore, serves the dual purpose of obtaining fuel gas for domestic purposes and a residual sludge which is an excellent fertilizer.

13.5.3 *The Process in Brief*—The process is simple and does not require any supervision whatsoever. It consists of anaerobic fermentation of dung in a closed receptacle called the digester. Animal dung mixed with an equal quantity of water is fed into the digester. To start fermentation from fresh dung takes considerable time, about 4 weeks in winter and 3 weeks in summer. The gas consists mostly of methane and burns freely when lighted. Once gas fermentation starts, the feed of dung slurry is kept regular, the quantity depending upon the capacity of digester. The gas collects in the gas holder to be used for cooking or lighting as and when required. The digested slurry overflows from the digester into the effluent tank from where it can be bucketted out and used as such for manuring or spread on sand beds and dried in the sun and stored for use as manure when required

13.5.4 *The Plant*—Fig. 3 shows the gobar-gas plant of 2·8 cu m capacity designed by Planning, Research and Action Institute, Lucknow. The cost of the plant is about Rs. 500. In many States, Khadi and Village Industries Board provides subsidy to persons who install gobar-gas plants.

13.5.5 *Other Useful Data*—The gas consumption per head may be taken as 0·4 cu m. About 6 cu m of gas is produced per 100 kg of animal dung. The climate and mean daily temperature variations have a direct effect on the efficiency of gas production.

The gas generated from the gobar gas plant is essentially a mixture of methane (65-70 per cent) and carbon-dioxide (25 to 30 per cent) with small quantities of nitrogen and oxygen (5 per cent). It is odourless and has a calorific value of 6000 k cal per cu m. As a fuel it is richer than coal gas. It burns with a smokeless blue flame and leaves no odour or residue behind and makes cooking clean, neat and speedy. Cooking burners of various types are manufactured by a Calcutta firm.

The gas can also be used for lighting purposes for which suitable lamps are obtainable. The intensity of the light obtained from the village type gas plant may sometimes not be satisfactory due to the low pressure at which the gas is delivered. This can be improved by passing the gas before it enters the lamp through a simple tin trap containing some petrol, gas passing through the trap is enriched and gives satisfactory illumination (Fig. 4).

The residual effluent running out of the digester is free of any foul odour associated with normal dung and supports no fly or mosquito breeding in it. It contains approximately 2 per cent available nitrogen on dry basis and acts as an excellent manure.

13.5.6 It will be obvious from the foregoing that anaerobic fermentation of animal dung is the best solution to its economic utilization and that even small units could be set up to operate on sound and profitable basis. The contribution that such units will make to the national economy is vast and will lead to substantial relief from the acute shortage of fuels and fertilizers.

13.6 Composting

13.6.1 Composting offers, to rural areas in need of soil nutrients, a method of disposal and reclamation of waste materials, which is not only sanitary but also valuable to the economy of the village and its agricultural community.

13.6.2 The method which is very suitable for individual families in rural areas is to dump the animal dung and other garbage in a pit outside the village near their fields. The pits should be about 1·2 m deep and the width and length should be adjusted to give the required capacity for a year. A maximum length of 6 m and a length to width ratio of 4:1 is satisfactory. It is desirable to provide 2 pits instead of one when the size is larger. Pit lining is not desirable. The sides have to be adequately sloped so that they stand by their own angle of repose. If the soil is loose, lining with bricks may be needed. The bricks should be laid dry without any jointing material.

It is advisable to cover each day's animal dung thrown into the pit with the house sweepings and ash produced in their ovens. This reduces fly breeding. When the pit is filled, it is allowed to undergo complete digestion for another 3 months and then used as a manure.

13.6.3 For carrying out composting operations on a large scale, two methods are generally followed; the pit method and the stack method. The pits are 5 to 9 m. long, 1·5 to 2·5 m wide and about 1 m deep. The stacks are about 2·5 m square and 1·2 to 1·5 m high. Complete details of the process of composting have been given in the publication "Composting—Sanitary Disposal and Reclamation of Organic Wastes" by H. B. Gotaas, published by the World Health Organisation.

13.7 Smokeless Chulha

13.7.1 Smoke nuisance is a great public health problem. Smoke not only affects environmental sanitation, but also is the major cause of serious eye diseases amongst women folk in rural areas. By using a smokeless chulha

not only the environmental stnitation and health of women folk is improved but it also results in fuel economy due to efficient burning of fuel.

13.7.2 A number of designs for smokeless chulhas have been evolved in various parts of the country. These designs were tested under laboratory conditions at Extension-*cum*-Training Centre, Bakshi-Ka-Talab, Lucknow and Planning, Research and Action Institute, Lucknow. After a series of experiments, a chulha known as "Bakshi-Ka-Talab" type smokeless chulha has been evolved which eliminates smoke and gives higher thermal efficiency. The details of construction of this type of chulha have been given in the following paragraphs. *See* Fig. 5.

13.7.3 *Materials Required*

1. Properly prepared mud paste—4 baskets.
2. Bhoosa—2 kg.
3. Locally burnt clay pipes for chimney (100 mm diameter below and tapering to 90 mm at the top).
4. Dampers
   (a) 15 cm × 12·5 cm —perforated.
   (b) 22·5 cm × 11·5 cm—unperforated.

13.7.4 *Method of Construction*—First make a block of the prepared mud paste in the shape of platform measuring 75 cm x 40 cm x 20 cm. The platform has to be properly rammed. If it be feasible to carve out the openings of first and second pot seats at that very time it may be done according to the size and specifications given in the drawings. After the pot seats, the passage connecting the two pot seats and the passage to the chimney have been carved out, the chulha should be plastered with mud mixed with bhoosa. This will afford durability. The chimney is built of clay pipes placed one on top of the other and projected beyond the roof by 60 cm. Over the burnt clay pipes a thick plaster of mud mixed with bhoosa is applied so that the chimney is kept intact and protected. The cowl is placed over the last burnt pipe piece of the chimney over the roof to prevent entry of rain water.

The first pot seat opening is of 17·5 cm and the second 15 cm in diameter. The passage connecting the two pot seats and the chimney is throughout 11·5 cm wide. The space below the chimney and to the second perforated damper is 20 cm deep. The second perforated damper is placed 7·5 cm from the second pot seat and is not disturbed during cooking. The first damper is placed horizontally in between the two pot seats which acts as a control for transfer of heat from first pot to the second pot. From the second pot seat towards the first oven there is a slope from a height of 11·5 cm from below and this can be correctly adjusted by measuring the inner side of the first oven towards the second pot where the passage connecting the two chambers should be 11·5 cm x 11·5 cm. Again to ascertain whether the gradual slope is further correct it is worthwhile to see that the measurement in the second pot towards the first chamber is 11·5 cm x 10 cm. The distance between the two pot seats is 7·5 cm.

In the centre of the second pot seat a baffle wall is erected 3·5 cm thick which should be 5 cm below from the top of the platform. By doing so, the flames will strike the pot and the smoke will find its way to the flue pipe. The height of the bame will towards the grate area is 7·5 cm and towards the chimney it is 6·5 cm.

The drawing attached will be of help in the construction of the chulha. The cost of the chulha is within the means of all, as the materials required are locally available and can be made easily.

13.7.5 *Cost*—The cost of construction of Bakshi-Ka-Talab type smokeless chulha comes to about Rs. 3·50. A mould for making these chulhas quickly is also available. The mould costs Rs. 80. With the help of the mould the cost is reduced to Rs. 3·00 per chulha.

13.8 Disposal of Sullage and Storm Water

13.8.1 As the consumption of water in rural areas is restricted, the quantity of sullage water is not appreciable. This water can be used in a kitchen garden in the back courtyard.

13.8.2 The waste water from the village well should be led through a drain to a nearby pond or field.

13.8.3 Where the quantity of sullage water is appreciable surface drains should be provided to carry the waste water. The drain should be of semicircular or U-shape, as drains of these shapes can be kept clean more easily. The drains may be of brick or stone. Sometimes special U-shaped bricks are also manufactured. Drains can also be constructed with soil-cement. The Rural Housing Wing Roorkee has constructed soil-cement drains with 5 per cent cement and they are standing well.

13.8.4 Apart from the disposal of waste water, some arrangement for the drainage of rain water is also necessary. The village economy at present cannot, however, bear the cost of regular storm water drains and reliance has to be placed on kutcha or natural drainage for the purpose. That is why villages are usually located on high ground, so that the rain water may flow to the surrounding areas by gravity. It is not an uncommon sight, however, to come across a village virtually converted into an island during the rainy season, because of pits formed all round due to digging that has been taking place for the construction and upkeep of the houses. To prevent the rain water collecting in pools and pits in a village, it is essential that all depressions should be suitably filled, and indiscriminate digging of earth for the construction of houses stopped.

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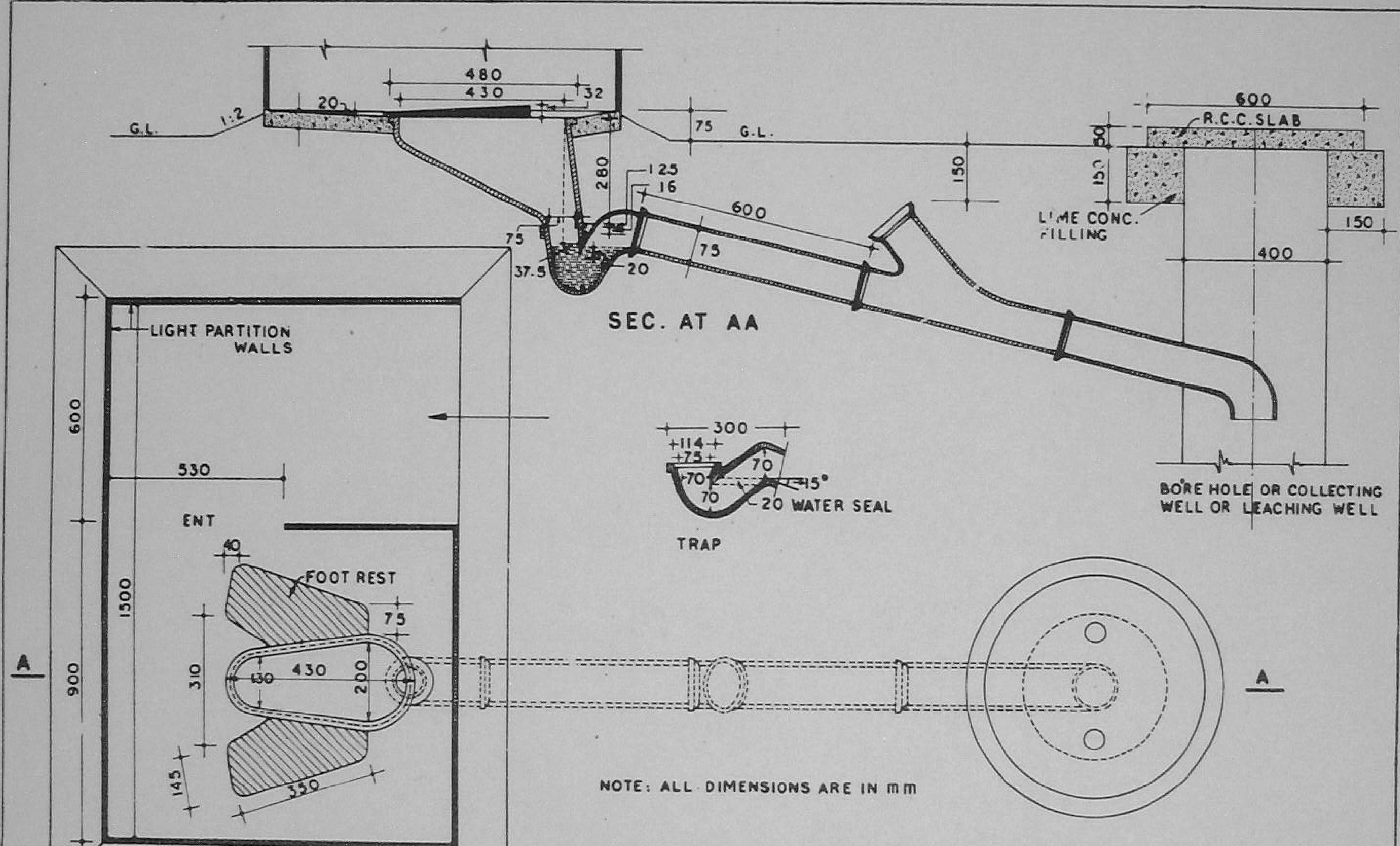


SANITARY RURAL LATRINE
(WATER CLOSET CONNECTED TO THE BORE HOLE)

Fig. 1A

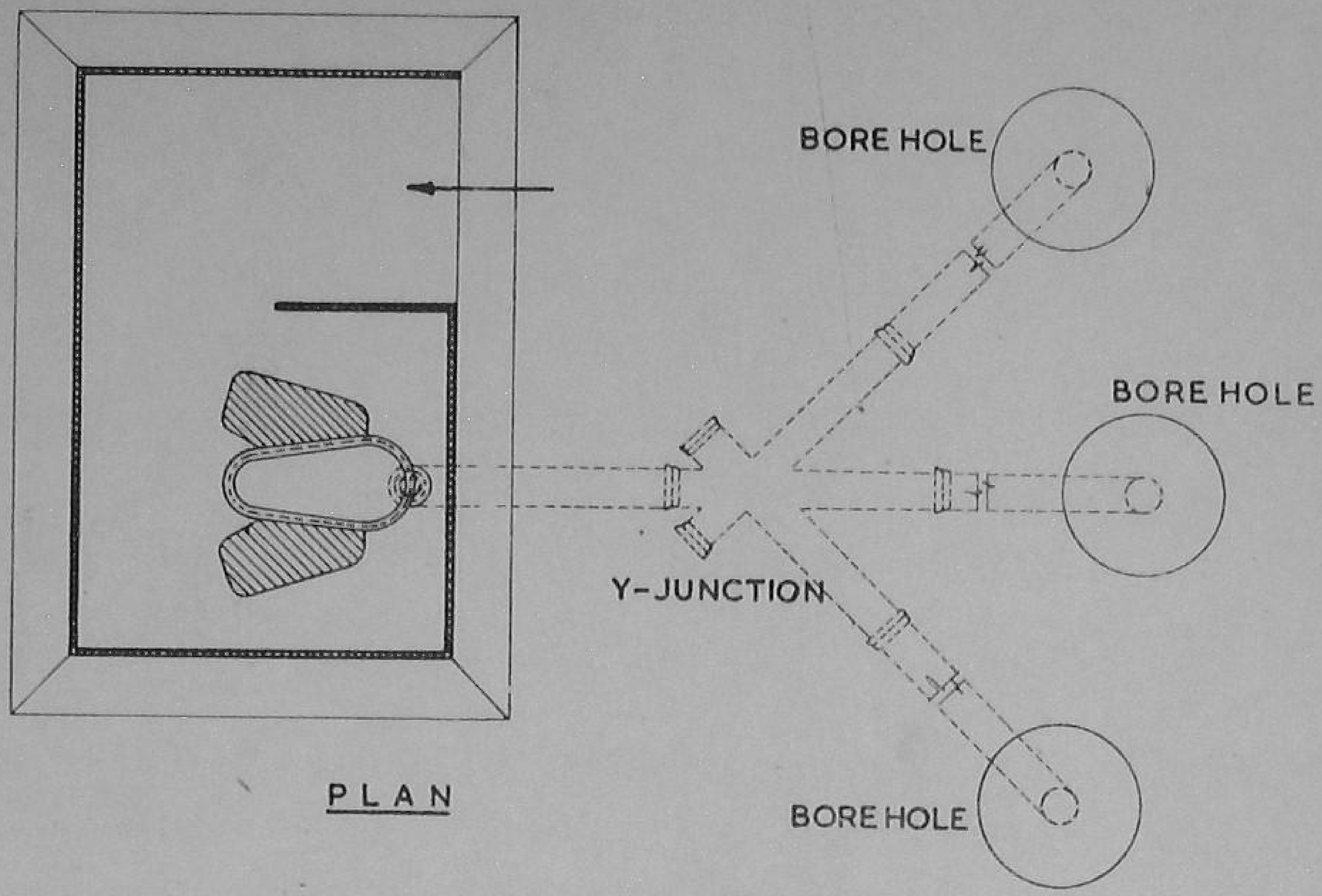
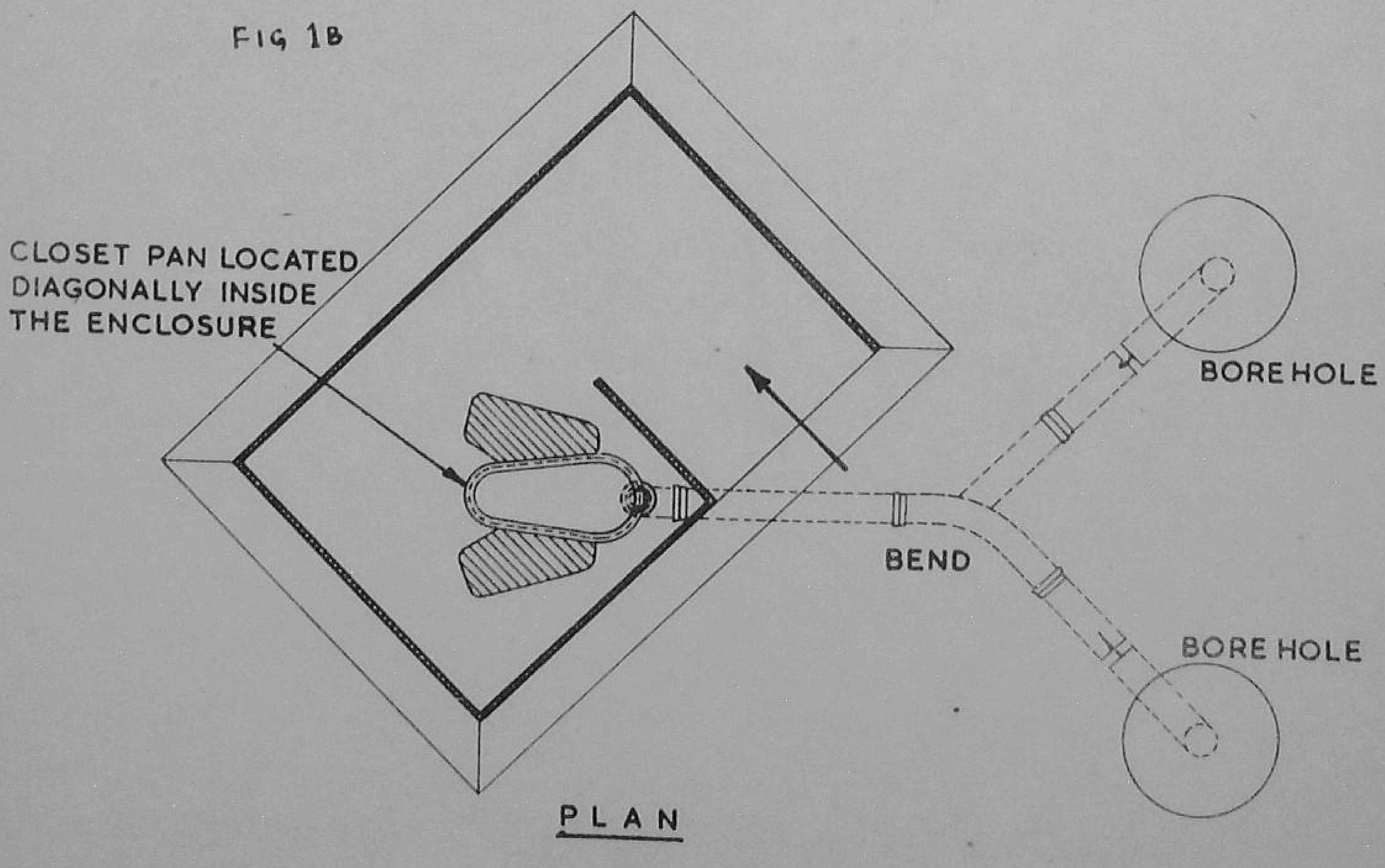

BORE HOLE
BORE HOLE
Y-JUNCTION
BORE HOLE
PLAN

FIG 1B


CLOSET PAN LOCATED
DIAGONALLY INSIDE
THE ENCLOSURE
BORE HOLE
BEND
BORE HOLE

PLAN

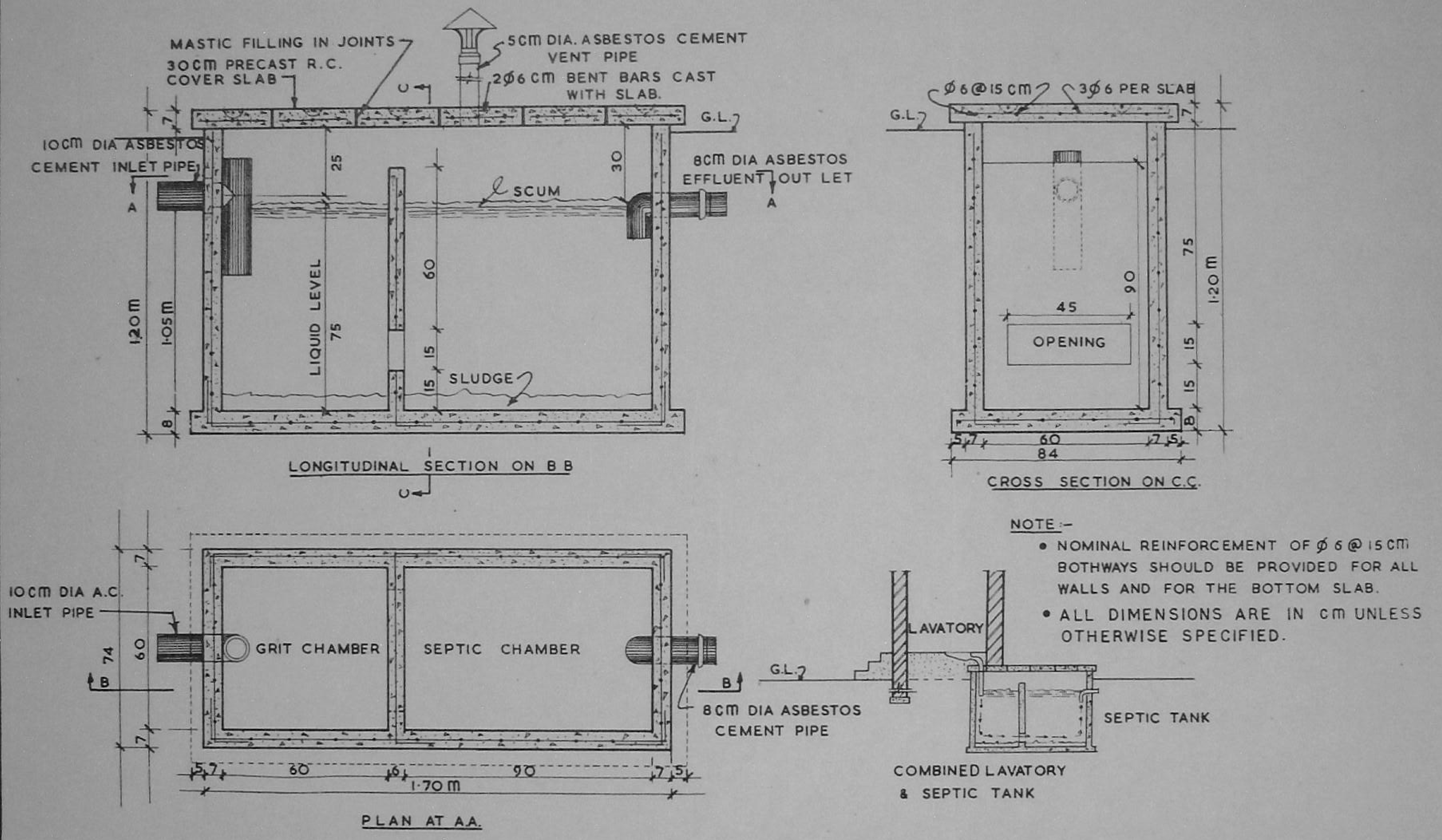
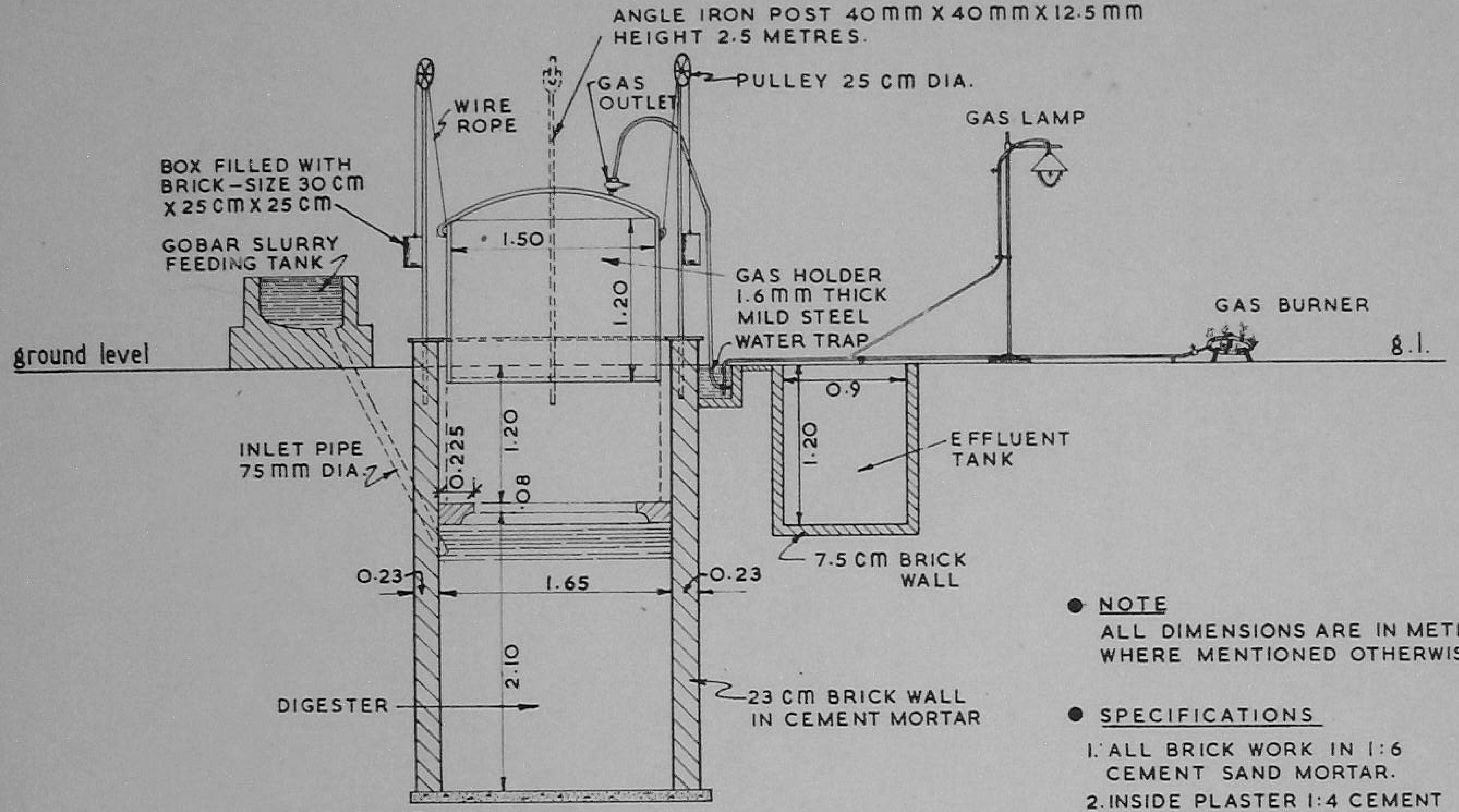
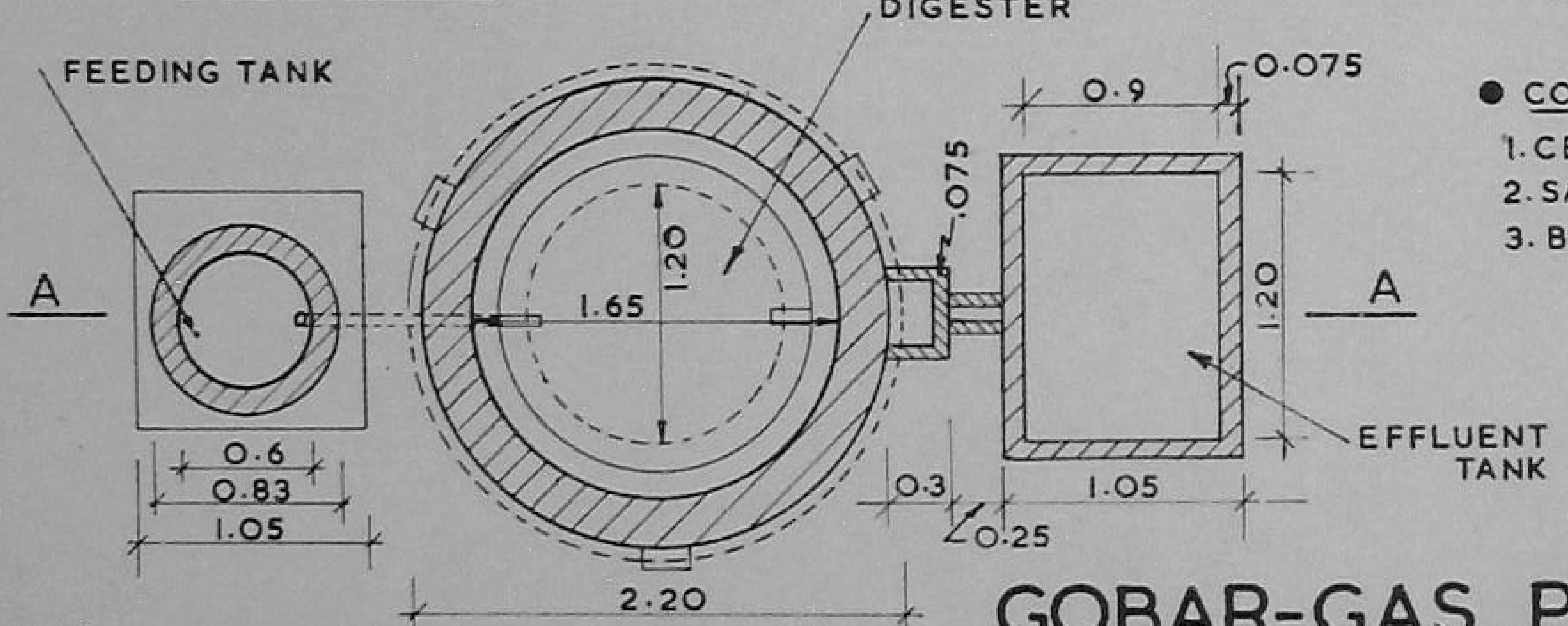


FIG. 2 CONCRETE SEPTIC TANK SUITABLE FOR FIVE USERS



SECTION AT AA



PLAN

- NOTE

  ALL DIMENSIONS ARE IN METRE EXCEPT WHERE MENTIONED OTHERWISE.

- SPECIFICATIONS

  1. ALL BRICK WORK IN 1:6 CEMENT SAND MORTAR.
  2. INSIDE PLASTER 1:4 CEMENT SAND MORTAR.

- CONSTRUCTIVE MATERIALS

  1. CEMENT 5 TO 7 BAGS.
  2. SAND 1.7 CU. METRE.
  3. BRICK 2ND CLASS 2500.

FIG. 3.

GOBAR-GAS PLANT FOR 2.8 CU. M CAPACITY

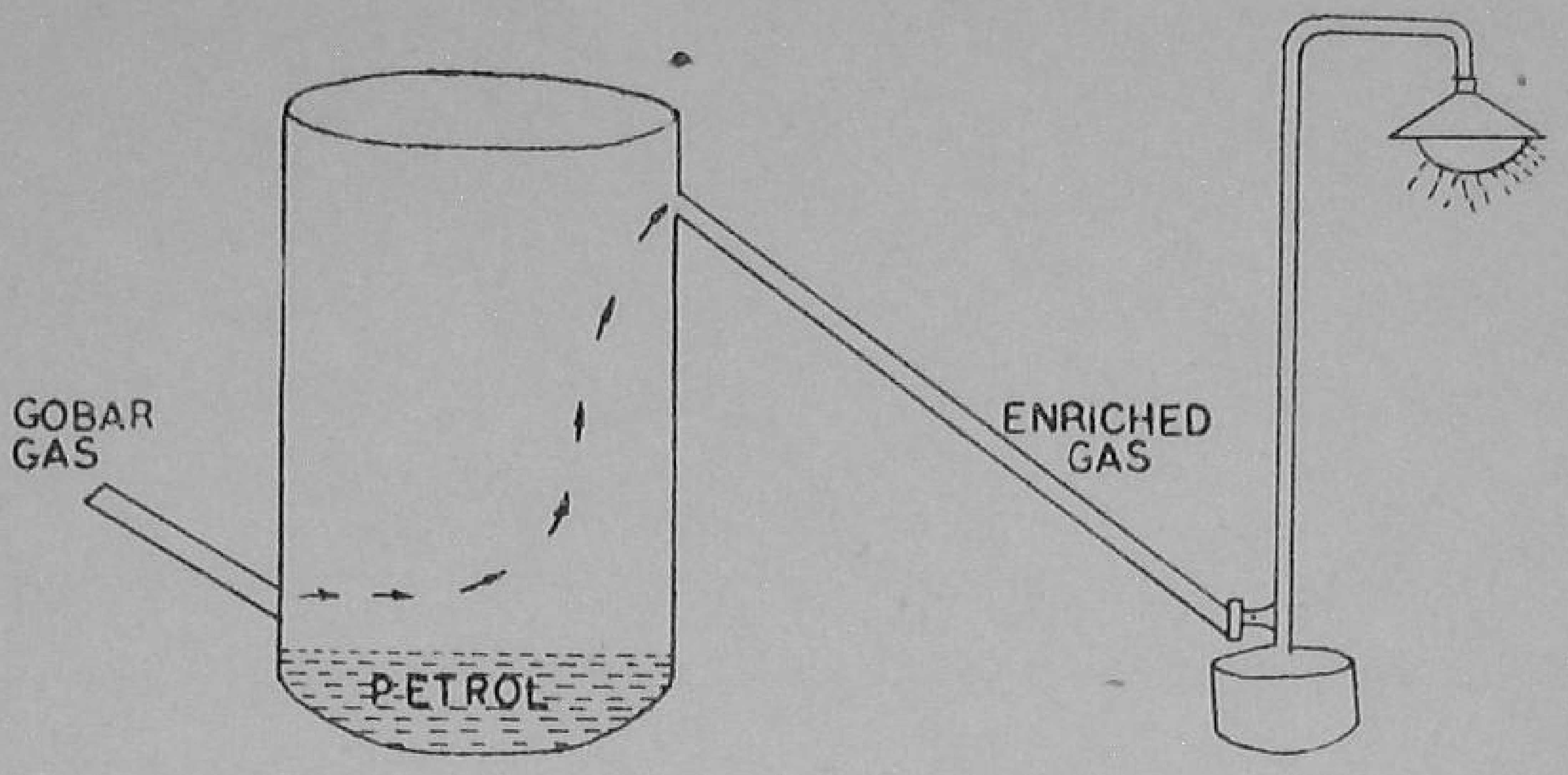


FIG 4. GOBAR GAS ENRICHMENT FOR LIGHTING.

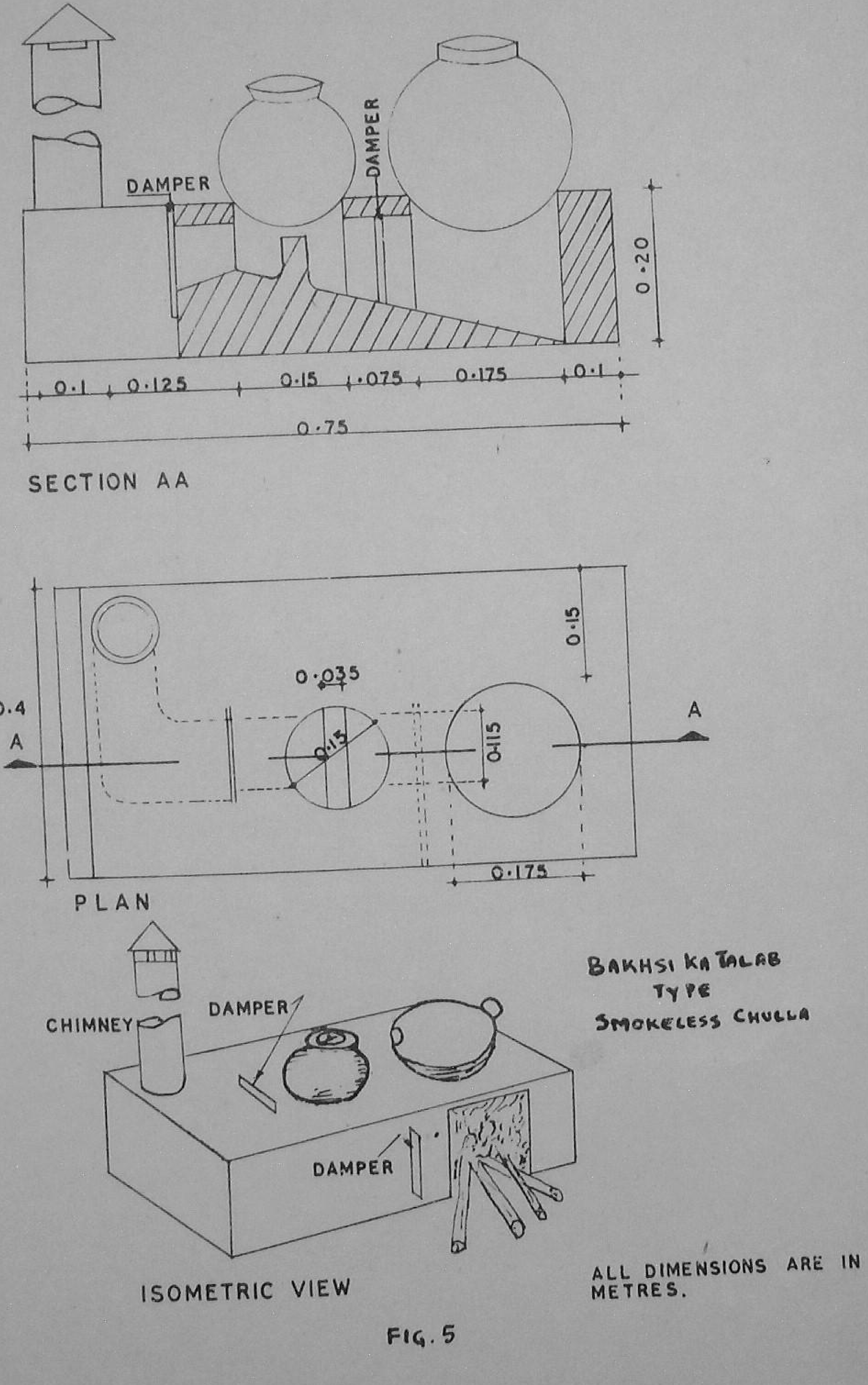

DAMPER
DAMPER
0.20
0.1
0.125
0.15
.075
0.175
0.1
0.75
SECTION AA
0.035
0.15
0.4
A
0.15
0.115
A
0.175
PLAN
CHIMNEY
DAMPER
DAMPER
ISOMETRIC VIEW
BAKHSI KA TALAB
TYPE
SMOKELESS CHULLA
ALL DIMENSIONS ARE IN METRES.

FIG. 5

14 Rural Landscape, Arboriculture and Horticulture

14.1 General

14.1.1 The countryside and rural areas are generally ery rich in natural landscape and scenic values. Fortuna- ly, the pattern of agriculture and organic growth of Indian 'lages has maintained the harmoneously blended and igenous character of the rural environments. The ortance of countryside as a recreational resource both the village and urban folk cannot be over-emphasised. 's, therefore, very essential that all the development and age planning schemes must be handled carefully and sensitively with due regard to the inherent potentialities of the rural landscape and its relationship to the neighbouring habitations.

14.2 Rural Arboriculture

14.2.1 The beauty of country-side depends upon the nature and extent of vegetation present in the area. Apart from its landscape value the vegetation also caters for the daily needs of fuel, fodder, building and other economic activities of the rural communities. The planting of trees, bamboos and grasses has, therefore, great significance in the development of rural areas. Great stress has been laid on the afforestation schemes to utilise wastelands and uncultivable areas, besides developing farm-forests, grasslands, shelter belts, groves, orchards and roadside avenues for augmenting this essential resource of rural life. The development and conservation of vegetation is also very helpful for the preservation of wild life, checking of the moisture evaporation and erosion of the land.

14.2.2 *Planting of Pasture Land*—Pasture land is essential for the grazing of the cattle. Where large areas cannot be earmarked for the development of grasslands, fuel-*cum*-fodder forests as village commons or village preserves can be added to utilise the inferior tracts of lands. Also planting of trees in conjunction with the grasslands helps to conserve moisture so necessary for the preservation of grass in areas with scanty rainfall. The species suitable for yielding fuel, fodder, timber or fruits are recommended provided these are hardy, quick-growing and need less protection from grazing animals and do not restrict the growth of grass underneath. Grasses generally do not thrive under mango, tamarind, peepal, siris, bair and bamboos. Species like babul and shisham are good in that they provide timber for the manufacture of village implements and they do not adversely affect the growth of grasses underneath.

Some 50 to 60 species of grasses can grow throughout India and majority of these can thrive anywhere. About 20 of these species are excellent for fodder purposes. Certain species are perennial and grow throughout the year whereas others appear during the monsoon like other herbaceous plants. The choice of grasses must be related to the soil, climate and need of the community. Although most of the grasses grow naturally, for richer yields, proper ploughing and seeding is necessary. The required information about a number of selected species has been compiled in Table 1 for general guidance.

TABLE 1

SPECIES OF GRASS SUITABLE FOR PASTURE LAND

(From : Farm Manual by Williams and Meagher)

Local Names					Perennial (P) or Monsoon (M)
U.P.	W. Bengal	Madras	Punjab	Maharashtra	
Lautanawa	Maliyar	Sewam Pilla	Palwan	Janjina	(P)
Anjan (hairy)	Sivala	..	Dhamman	Jiral	(P)
Dub	Doorba	Huriali	Khabbab	Haraili	(P)
Musal	Durhi ghase	Bhashrappa	Gandhi	Musar	(M)
Siuri	Makuriali	Panapal	Yaarakari	Chikeri	(M)
Makra	Mugha	Ragi	Mandwa	Mandaya	(M)
Sewain	Dul	Peddawonao	Samvaki	Honna	(M)
Sanwal	Shama	Woodoogodi	Janlisanwak	Gawa	(M)
Chupraila	Jaloganti	Kobachipina	Buriya	Somwan	(M)
Bharwi	Baroo	Kodyapul	Burron	Baroo leads	(P)
Sen	S n	Colypillu	Sin	Gawan	(P)
Bhuru	Titar	Gonair	Ghandi	Biggodah	(P)
Motha	Motai	Midaipilla	Dela	Biggodah	(P)
Ganrar	Bena	Vetwar Pilla	Panni	Urai	(P)
Kansa	Khajara	Pellogadi	Kana	Karagadi	(P)
Rasaura	Khujusia	Urenki	Lumra	Lalbuli	(M)
Baghai	Babuz	..	Bhabar	Nulka-gadi	(P)
Ullu or lla	Usar-ki-ghas	..	Sandua	..	(M)
Kusa	Devolia	Durbha	Dab	Dabhat	(M)
Sarpat	Shur	Sarghas	Sarkanda	..	(M)

14.2.3 *Planting of Bamboo Groves*—A surprisingly wide range of purposes can be served by bamboos in village life; it can be used for buildings, furniture, and other cottage industries; it can be used as fuel and fodder. In almost all parts of the country some variety or the other of bamboos can grow provided the area is not waterlogged and has 750 mm to 5000 mm of rainfall. A good deep loamy soil is better suited than heavy soils for the cultivation of bamboos. It yields quick money crop and offers sustained annual yield, because it attains full growth within 4 to 12 years. Therefore, it is quite useful to reclaim wastelands or derelict areas by planting suitable species of bamboos. Even small narrow spaces can be planted with bamboos for adding variety to the landscape.

The artificial planting can be done with the help of seeds, seedlings, cuttings and separating of rhizomes. Before planting, the area should be ploughed and fenced. It is necessary that the planting holes should be prepared two months ahead of the planting time. The spacing of holes for dwarf varieties ranging from 3 to 3·5 m in height should be kept 5 to 6 m in both the directions and the taller species may be spaced accordingly. The rhizomes and offsets should be carefully collected and stored to avoid damage to the buds and these should be placed in puddled mud under shade and not exposed to sun. Planting can be taken up immediately after the first shower of the monsoon. It is necessary to protect the plantation from rats, hares, pigs, deer, cattle, man, monkey and insects which hamper their growth.

The bamboos generally extend peripherally and thinnir of culms after a lapse of three to four years in dry are and two to three years in damper areas can be resor to in formulating the working plan. It is better to le a few matured bamboos and all immature ones during felling. The centre of the clump needs heavy thim to promote further growth. All dry, dead, insect infec and ill-shaped culms should be cleared so that the grov can thrive properly. Details of 7 species of bamboos have been given in Table 2.

TABLE 2

SPECIES OF BAMBOOS

Sl. No.	Scientific Name	Local Names	Availability	Height	Dia.	Walls
1.	Bambusa arundinacea	Kanta, Katua, Ketausi ban,	Orissa. Throughout except Himalayas/ sub-Himalayas	24 to 30 m	150 to 200 mm	thick
2.	Banbusa nutans	Makla, Mala, maplu bans	W. Bengal	12 m	..	thick
3.	Bambusa tulde	Jaotha, Jati, Jao, Kiranti or deobans	W. Bengal, Tehri	20 m	..	thick
4.	Dencrocalamus hamiltonii	Choya, Tama bans	Lower Hills of Sub-Himalayas	18 to 24 m	150 to 200 mm	thick
5.	Deudrocalamus strictus	Kanta, Karail bans	All over moderately dry or extremely dry regions	6 to 15 m	25 to 75 mm	thick
6.	Melocanna bambasoides	Muli bans	Assam, W. Bengal	10 to 15 m	40 to 60 mm	thin
7.	Oxytenanthera nigrociliata	..	NEFA, Goa, Orissa, M. P.	10 to 15 m	100 mm	thin

14.2.4 *Planning of Shelter Belts and Wind Breaks*—The importance of planting shelter belts and wind breaks in arid zones has long been recognised for the protection of agriculture and conservation of moisture. Experiments have shown that the humidity increases considerably and the evaporation is reduced by 20 to 30 per cent, if the area is suitably protected by the shelter belts. Also the rate of transpiration reduces and moisture in the soil increases when the wind velocity is checked with the help of wind breaks. A shelter belt is a unique tool to check wind erosion, besides moderating the extremes of climate and presenting liveable and pleasant environments.

Trees or shrubs with light crowns, good branching systems and deep roots are generally preferred for the planting of shelter belts and wind breaks. The species which shed leaves during non-windy seasons offer further advantages. It is always better to select native species or properly tried out exotics. Normally three to five rows of the same species can be used unless triangular planting with mixed species is necessary to withstand the strong winds. While selecting the species the ease of thinning and lopping is carefully examined, besides their suitability to furnish fodder, fuel, timber and other raw materials for the village industries. The spacing of the shrubs and trees varies in accordance with the required density and growth characteristics of the species. The names of the species suggested for the arid zone are given below:

1. Acacia arabica.
2. Acacia catechn.
3. Acacia cyanophylla.
4. Albizzia lebbeck.
5. Azadirachta indica.
6. Balanitis Roxbergii.
7. Dalbergia sissoo.
8. Dodonia viscosa.
9. Eucalyptus species.
10. Eugenia Jambolana.
11. Gymnosporia montana.
12. Inga dulcis.
13. Parkinsonia aculeata.
14. Prosopis juli flora.
15. Prosopis spicigera.
16. Saccharum munja.
17. Salvadora species.
18. Tamazix articulata.

14.2.5 *Planting of Roadside Trees*—Apart from other landscape developments, the beauty of roadside and richness of travellers experience depends upon the proper selection and placement of trees and shrubs in relation to the spatial quality of the area and nature of the surrounding vegetation. The prime aims and objectives of the roadside planting include:

(a) Shade for the travellers,

(b) Additional food supply,

(c) A fodder reserve during famines,

(d) A source of income, and

(e) Improvement of the landscape.

hus, the selection of the species must be made with ue regards to the above requirements. A choice from the pecies hardly to frost, flooding and draught helps to reduce ie maintenance problems. Species which are shallow-oted, hazardous and susceptible to quick decay must be avoided. For pleasing effects trees with different forms, bark textures and colour of foliage, flowers and fruits can be selected for a good combination of seasonal variations. The following species are most suitable for planting on road sides:

1. Babul.
2. Siris.
3. Gulmohar.
4. Jaman.
5. Bar.
6. Peepal.
7. Mango.
8. Molsari.
9. Ashok.
10. Neem.
11. Khair.
12. Kadamb.
13. Karanj.
14. Semal.
15. Kathal.
16. Kachnar.
17. Mahuva.
18. Imli.

14.2.5.1 *Spacing and arrangement*—The optimum distance between adjacent trees on the roads will obviously depend on the species and no hard and fast rules could be laid down. The trees should be planted so far from the road as not to injure the crops in neighbouring fields and to leave the road un-shaded. The arrangement of rows will also have to give due consideration to the position of telegraphs and electric wires, side-drains, curvature of the road, etc. The best distance for the above species will be 3 m away from the outer edge of the berm *i.e.* for a 7·5 m wide road the rows will be 13·5 m apart, and 9 to 12 m between tree to tree in a row, 10 m being taken as a good average.

On curves, near level crossings and cross roads, either trees of high crown should be planted or a tree should be omitted to give a clear view of the crossing.

The trees may either be planted opposite to each other on either side of the road, or staggered uniformly.

14.2.5.2 *Digging and filling the pits*—The pits for the reception of the young tree should be 1·2 m deep and 100 m. square or 100 mm in diameter. As far as possible the pits should be dug during the cold weather and should be left exposed to the sun till the beginning of the rains, and be filled with good soil, and 30 cm. compost or cow-dung manure, mixed with the soil. A sufficiently deep and broad hole should be made in the centre of the pit; the young plant with the ball of earth should be inserted in the hole and the root covered with earth. The injury to the roots should be avoided. If leaves are nipped off, transpiration would be prevented. Only one plant should be planted in each pit.

The level of the ground at which trees are planted is a matter of importance. If it is much above the surrounding ground, the danger of injury from draught is increased, while, if it is below the surrounding soil, too much water collects round the young tree; so to avoid these, it is essential that drainage should be provided at least during the rainy season.

The trees after planting should be watered immediately unless it is raining.

14.2.5.3 *Protection*—For the first few years of their life, young trees will have to be protected against stray cattle; for this purpose, different contrivances, may be used to suit the locality and the availability of materials:—

(a) *Iron guards or asphalt drums.*

(b) *Wooden guards*—These should be wider at the base.

(c) *Open brick work guards*—They do not let in enough light. This is a disadvantage of this method.

(d) *Bamboo cylinders*—Where bamboos are cheap, they can be used with advantage.

(e) *Thorns*—They are useful when a tree is small, and require constant attention as gaps are apt to form in them, and cattle may get inside and damage the tree.

(f) *Mud walls*—These also keep out the light. They should allow plenty of room and the top should be covered with thorns to keep out the cattle.

(g) In places, where any of the above methods are not practicable, a trench combined with sloping bank is better than nothing. A trench 60 cm wide and 75 cm deep should be dug around the tree.

14.2.5.4 *Watering*—Delicate species, such as mango and nearly all the plants except a few require watering for the first 2-3 years of their early life. Any of the following processes for watering can be adopted.

(i) *Flooding system*—Consists in taking out the earth in trench around the stem and filling it with water. In this method much water is lost by evaporation.

(ii) *Watering by percolation*—Through 'gharas' embedded in the pits.

(iii) *Direct watering through bamboo tubes (or earthen 'nalia')*—In this system bamboo tube 80 mm in diameter and 30 to 50 cm long is inserted obliquely into the pit with the upper head above the ground level and the lower end towards the centre of the pit. Water is poured into the tube through cane. The moisture is confined to the lower half of the pit and roots are thus forced to work downwards.

14.2.5.5 Trees derive a great deal of benefit from periodical deep working of the soil in the pit than even watering. The earth should be loosened to a depth of 15 to 20 cm. with a hand fork and exposed to the sun for 24 hours and then watered. Besides this, timely pruning is also required to give proper shape to the plant.

14.3 Planting of Fruit Trees

14.3.1 For building up a sound base for the rural economy the planting of fruit trees and orchards cannot be over-emphasised as every region or place has suitable

conditions for growing fruits for local consumption and for export. In planting fruit trees suitable sites should be earmarked and suitable species of fruit trees should be selected taking into account the local climate and soil conditions.

14.3.2 *Planning of Orchards*—Before undertaking the actual planting work, a plan of the orchard should be prepared, preferably on a graph paper. In this connection, the following points should be borne in mind:

1. If more than one kind of fruit are to be planted, each kind or variety should be ordinarily in a block by itself.
2. Large trees should be on one side and smaller ones on the other. Intermediate categories can come in-between.
3. Fruits ripening in the same season should be grouped together for convenience in watch and ward and picking.
4. If the soil in the different parts of the orchard is of different types, each type should be made into a separate block and planted with the species for which it is best suited.
5. In some fruits, such as cherry, plum, apple and almond, certain varieties are self-sterile. Hence, occasional trees of a different variety known to pollinate these, should be planted with them in the blocks. A system commonly adopted is to have every third tree in every third row belonging to the pollenizing variety.

14.3.3 *Planting Systems*—For an aesthetic look of the orchard as well as for convenience in cultural operations, the trees should be planted in straight rows according to some set plan. This should provide for the maximum number of trees per hectare consistent with space requirement for the proper development of each tree. If the land is rugged and steep, the trees must follow the contour of the land. A number of planting systems are in vogue. The more important amongst these are Spare System, Diagonal System and Hexagonal System:—

1. *Square System*—In this system, the orchard space is divided into squares, and the trees are planted at the four corners of the square, in straight rows running at right angles. This is a very convenient system, and is easy to understand and lay out. It allows of cultivation and irrigation in two directions, and is the most popular plan used all over the world.

2. *Diagonal System*—It is a modification of the square system, with a fifth tree in the centre of the square. It is generally used when planting short-lived trees like peach, plum and grapevine as fillers in the centre of the square, with long-lived and slow-growing trees like mango, litchi, apple or pear planted at the four corners of the square. This system results in overcrowding, with no clear space left for carrying out cultural operations. The filler trees, therefore, should be removed after a few years. The system should be adopted in cases where the distance between the permanent trees is at least 10 m; otherwise it is better to put the interspaces under vegetables or other leguminous crops, depending on the facilities for irrigation and manuring.

3. *Hexagonal System*—This system is also known as equilateral triangle system as the trees are planted at the corners of an equilateral triangle. The planting thus forms the pattern of six trees at the corners of a hexagon with one more tree in the centre.

14.3.4 *Spacing of Trees*—Most old orchards in India had been planted rather too closely and for this reason they suffer from many defects. The trees, for want of space, grow tall and slender and suffer more from injury by strong wind than low-headed trees. Besides, the cost of picking fruit, spraying, pruning, etc, is also comparatively higher in the case of such trees. They bear much less fruit than the spreading trees, as the fruit is borne mostly on the top branches exposed to sunlight. The fruit is poor in quality, colour and size. The trees suffer from various diseases and insect pests, which find very congenial conditions for their spread. The trees appear sickly with plenty of dead wood. Cultivation by bullocks is not possible in such orchards, while cultivation by manual labour is not economical. Weeds and grass grow in abundance and sap the vitality of trees, resulting in their earl decline and premature death.

The optimum development of a tree requires suc spacing that the tree may not come into competition wi the neighbouring trees. The roots of trees extend a litt farther than the above-ground spread of the tree, and avoid competition among the roots of adjacent trees, it essential that the spacing is such as will not allow tl branches of the trees to touch, when they have attair the maximum size.

The great bulk of the fruit produced in the lifetime of an orchard is borne after the trees attain their full size. Most growers space the trees with a mental picture of the trees as they are in the first few years rather than as mature trees. A few years after planting, the over crowding becomes all too obvious. But then it is too late to remedy the situation.

Close planting may give a somewhat greater yield per hectare during the early life of the trees but the crop will be much less in the more important later years. The loss of some crop in the early years from adequate spacing can be offset by planting filler trees or vegetables and other suitable cash crops in the interspaces.

The spacing of trees is governed by the following factors:—

1. Type of Soil.
2. Varieties.
3. System of Irrigation.
4. Pruning.
5. Climate.

It is very difficult to suggest the exact planting distance that will suit every locality or soil. The fruitgrower must exercise his own judgment and discretion. However the planting distance given below for some of the important fruits may be considered as a safe guide for planting fruit orchards in the hilly areas in the north.

Fruits	Planting distance (metres)
Phalsa, grape, papaya and banana	3·0
Pomegranate	4·5
Kaghzi lime	5·5
Malta, lemon, sweet lime and sangtra	6·0
Peach, plum, almonds, pear & apricot	6·5
Apple, cherry, guava, loquat & litchi	7·5
Grafted ber, mulberry and grafted mango	9·0
Jaman, fig and aonla	10·5
Seedling mango and walnut	12·0

15 Miscellaneous Data

15.1 Rural Electrification

15.1.1. *Objectives of Rural Electrification*—The use of electricity can be broadly divided into two classes—lomestic purposes, such as lighting, fans, etc. and economi-ılly productive purposes, such as motive power for agri-tural and industrial operations. The former contributes ·omfortable living, but it is the latter which is more ·rtant from the point of view of economic development. ural population will, of course, welcome it if they ; provided with electricity for lighting and other ·es at a price they can afford; but, in order that y enjoy the benefits of electricity and other modern ·nces, their economic potential has also to be d.

use of electricity in various rural activities would augmenting economic output per worker. There-ıigh priority and emphasis should be placed on the ·cation of electric power for productive purposes in ıe fields of both agriculture and industry. Among the productive uses of electricity in the rural areas may be mentioned—irrigation and dewatering, processing of agricultural produce, such as corn grinding, rice hulling, oil pressing, sugar-cane crushing, etc, cold storage and preservation of food, fish, vegetable and fruits, and small scale and cottage industries, such as coconut coir industry, small weaving looms, ceramics, pottery and toy making.

Apart from the productive uses of electricity, one cannot ignore the comforts and amenities resulting in a better living which it provides. Its special importance arises from the need to discourage people from gravitating to the towns and cities. The rural folk send their children to the nearest cities or towns for their education and, while there, these children enjoy many amenities which are lacking in their own villages. Hence they feel unhappy on their return to the villages and, instead of staying there to help develop the rural economy, they often prefer to go back to work in the towns, even for relatively low salaries. Apart from depleting the villages of young and educated people well fitted to sustain and develop the rural economy, this causes serious social problems, such as overcrowding, unemployment, etc, in the towns.

15.1.2 *Generation & Distribution of Power*—The simplest and relatively least expensive method by which rural areas can be supplied power is to undertal. extensions from existing high voltage grid networks in their neighbourhoods. This immediately raises a limitation; because, in many regions of the country the extent of integrated high voltage grid networks is small and there are vast areas far away from the major generating and supply centres. In rural areas located not far from existing power networks, the problem of electrification involves distribution only. This is of great advantage, because the cost of energy generation in isolated and small power plants is relatively much higher than the costs of bulk supply from a large grid network.

There are a number of isolated areas where small hydro-plants of 10 to 100 kW each can be set up at modest cost. Small hydro units up to 100 kW capacity are now being manufactured in the country. In the long run, they will be more economical than diesel-alternator sets and relatively easy to maintain, and will not involve foreign exchange for their procurement or operation. A cell has been set up in the Central Water & Power Commission, Government of India, for initiating and assisting in field surveys and in the installation of such plants. This aspect of power development is of special importance in hill areas where suitable programmes should be formulated.

Generally speaking, the capital outlay per kW of diesel plants is not very high, but the expenses on fuel and maintenance are such that the overall cost of generation is usually much larger than in the case of hydro or steam stations. Nevertheless diesel stations serve a useful purpose; they help to build up loads in local areas in the initial stages and, when sufficient loads have been built up in a number of contiguous or neighbouring localities, it may become economical to extend connections from an integrated network or alternatively to build a large size central generating station.

Rural extensions of electricity become relatively uneconomic mainly because of distances separating individual villages, the low level of power consumption and the seasonal character of the requirements of power specially in agriculture. Consequently the load factor is low and the available generating capacity is not fully utilised. With a view to improving the load factor it is essential that different types of economic activities in each district requiring the use of power should be developed in a coordinated manner. This object can be secured through a carefully formulated development programme for each area covering activities in different fields of development, such as minor irrigation, credit and service facilities for equipment, improved seeds and village and small industries, so that rural electrification makes the maximum contribution possible to the increase of agricultural and industrial production. There should be forward planning for rural electrification over a period of two or more years ahead of taking up the work so that simultaneous action is initiated in other sectors also.

Electric Sub-stations—Normally the villages are supplied electricity by tapping off the nearest 11 kV lines by erecting a small capacity 25 k.V.A. pole mounting substation. In a village having say 1,000 to 1,500 population two transformers of 25 k.V.A. capacity each are sufficient to cater to the load demands of the village. If the population is of the order of 2,000 to 3,000 one transformer of 50 k.V.A. and another of 25 k.V.A. are quite sufficient. All these substations are pole mounting type and are erected at the cost of the State Electricity Board. The consumers are not to pay anything towards the cost of these substations either in the shape of the initial cost or rentals in lieu thereof.

Distribution—The local distribution system is designed to meet the likely growth of demand over a period of 10 years from the time of commencement of supply and the load development in tenth year of operation is estimated. It has been seen that in a normal average village the maximum demands are of the order of:—

General (lights and fans)	3 kW.
Industrial	5 kW.
Pumping (Irrigation)	12 kW.

15.1.3 *Types of Wiring System for Rural Houses*—The following types of wiring systems are suitable for rural areas:—

(a) Wood-casing Wiring System

(b) TRS (Tough Rubber-Sheathed) or PVC-Sheathed Wiring System.

The TRS or PVC-Sheathed cables should be run on well-seasoned teak wood battens of suitable width and not less than 10 mm thickness. The battens should be fixed to wooden plugs with flat-headed wood screws at an interval not exceeding 75 cm. The cables should be fixed to the battens with brass link clips and spaced at intervals of 10 cm in the case of horizontal runs and 15 cm in the case of vertical runs.

15.2 Village Roads

15.2.1 Roads form an important aspect of village planning. While preparing the village layout, it is essential to keep in view the requirements of land for roads and lanes.

15.2.2 *Width of Roads*—As already mentioned in Chapter 3, the pattern and width of roads depend upon the topography and other features and also on considerations of intensity and nature of traffic.

Local village streets are recommended to have a minimum width of 4·5 m. Streets passing through shopping centres or carrying through traffic to main streets should have a width of 9 m so that they may accommodate two lanes of traffic and side drains.

Main roads may be kept 12 to 18 m wide. Provision should also be made for open spaces for parking of bullock carts, etc.

15.2.3 In view of the mass road construction programmes and acute shortage of good materials and also with a view to lowering cost of construction an attempt has been made to evolve specifications for cheaper type of roads which are recommended for rural areas. The main among them are:—

(a) Stabilized soil roads.

(b) Soil cement roads.

15.2.4 *Stabilized Soil Roads*—As a result of research over a long time it has been found that it is possible to prevent road failure by suspending low grade aggregate in well graded soil, so that the strength of the resulting matrix is derived not from the interlock of the aggregates but from the cohesiveness of the soil mortar. This method of road construction has been evolved by Prof. S. R. Mehra, Director, Central Road Research Institute, New Delhi.

15.2.4.1 This specification is recommended for the following climatic and traffic conditions:

Rainfall—up to 1250 mm per year,

Subsoil water level—
Not less than 3 m below ground level.

Maximum mixed traffic—
50 tonnes per day for unsurfaced roads; 200 tonnes per day for surface treated roads and 500 tonnes per day for stone graft and surface treated roads.

NOTE:—Mixed traffic normally implies not more than about 30 per cent iron tyred traffic.

15.2.4.2. *Preparation of subgrade*—The subgrade should be properly rolled by means of 8 to 10 tons roller after sprinkling water and allowing it to soak overnight. The density of subgrade up to at least 15 cm. depth should not be less than 1·8 or 95 per cent of the laboratory density of the particular soil.

15.2.4.3 *Edging*—Brick on edge or gonda bund may be provided on the sides so that the base course and wearing course soils could be uniformly laid.

15.2.4.4 *Base course and wearing courses*

(A) *Without bituminous surface treatment*

(i) *Base course*

(a) The compacted thickness shall be at least 75 mm; for this purpose about 115 mm loose soil will be required.

(b) The soil used for base course shall have Plasticity Index of 4 to 7·5 and sand content not less than 50 per cent. The soil and water used for construction shoul be free from harmful salts like sodium sulphate who maximum content permissible is 0·15 per cent.

(c) The base course should have a camber of 1 i and final density should be not less than 1·8 or 95 pe of laboratory density.

(ii) *Wearing course*

(a) The minimum compacted thickness wil mm; in this case also 115 mm loose thicknes mixture will be required.

(b) The mixture will consist of 2 parts of s part of brick aggregate by volume.

(c) The soil shall have plasticity index of 9 to 11 sand content not less than 33 per cent. The maxi salt content permissible is 0·15 per cent.

The brick aggregate will not be under burnt and shall pass 100 per cent through 31·5 mm screen and will contain less than 20 per cent of size passing 6·3 mm screen. The crushing value of aggregate shall be 35 to 50. Ten per cent of aggregate may be kept for spreading whose crushing value shall be 40.

(B) *With Bituminous Surface Treatment*

The general description shall be same as per (A) above. Specifications in brief are however, given below:

(*i*) *Base course*

Soil P.I.	4 to 7·5
Sand Content	Not less than 50%
Sulphate Content	Not more than 0·15%

(*ii*) *Upper course*

Soil	Aggregate shall be as 2:1	
Soil P.I.	7·5 to 9·5	
Sand Content	Not less than 33%	
Sulphate Content	Not more than 0·15%	
Aggregate crushing value	..	35 to 50
Passing 31·5 mm screen	..	100%
Passing 6·3 mm screen	..	20%

The ten per cent aggregate to be spread on surface should have crushing value of not more than 40.

(*iii*) *Surface dressing*

Primer :

Bitumen 80/100 per	30%
Furnace oil	70%
Rate of spread	1 kg/sq m

Binder :

A tar or bitumen or cut-back considered suitable for ordinary surface dressing.

Grit:

This should be good quality, aggregate crushing value shall be 30.

(C) *With Stone Graft and Bituminous Surface Treatment*

The general description shall be same as for (A) above. Specifications in brief are as follows:

(i) & (ii) *Base course and upper course*—Same as for (B) above.

(iii) *Graft stone*—If it is desired to graft the surface with stone, 25 mm gauge stone metal is spread over the wearing course mixture before rolling at the rate of 2 to 2·4 cu m per 100 sq m The crushing value of aggregate used shall be 25.

(iv) *Surface dressing*—Specifications for Binder and grit shall be same as for (B) above.

15.2.4.5 *General construction procedure*

(a) *Preliminary soil survey*—A visual identification of soils along the entire length of the existing earth road or proposed alignment shall be done keeping in view the behaviour of different lengths under traffic, in diffrent weather conditions. Topographical data and figures of rainfall, etc, are also collected. The object of the survey is to fix the specifications.

(b) *Soil sampling*—As a certain amount of banking is necessary to keep the road immune from flooding, the soil for stabilization purpose has normally to be borrowed from areas outside the formation width of the road.

In the alluvial plains of India, the characteristics of the soil deposits change at short intervals, and therefore, soil samples are taken from fixed points which can be located when soil is to be actually borrowed.

Soil samples are taken at points 200 m apart and about 20 m from the centre line of the road. 30 cm (being the specified depth of borrow pits) depth of the soil is sampled after removing the top 2 to 4 cm foreign matter which may be in the form of grass or any other loose matter. A representative sample of about 2 kg in weight is obtained by the method of quartering, after mixing the entire quantity of soil dug out from 30 cm × 30 cm × 30 cm deep pit. For location of pit for subsequent borrowing of soil, a numbered peg is driven.

In addition to sampling at regular intervals, a few more samples of admixtures like fat clay and sand available at economical distances from the road shall be taken to facilitate blending.

Samples of local aggregate, such as brickbats, or any other local deposits of kankar, laterite, shale or coarse moorum, etc, are also collected. Samples of water which is likely to be used for construction shall be collected in glass bottles.

(c) *Despatch of Samples*—The samples shall be put in paper bag to avoid loss of fine material. This in turn shall be enclosed in a cloth bag to which a tag shall be tied describing the exact location. Similar information written on a paper shall be also enclosed in the bag itself. The samples may be despatched to the field laboratory for testing.

(d) *Testing of Samples*—The following routine tests shall be carried out:

(i) Sieve analysis.

(ii) Liquid limit (LL).

(iii) Plastic limit and plasticity index.

(iv) Sulphate content.

(e) *Sub-grade formation*—If the formation is already existing then the top 15 cm of the sub-grade shall be raked, pulverised and rolled back with 8-10 tonne roller at near optimum moisture. In case of a new formation, the top 30 cm of the embankment shall be compacted in loose layers of not more than 15 cm in the same manner as mentioned above. The desired moisture may be attained by flooding the borrow area.

(f) *Collection of soils*—Soils, as specified in the designed mixtures, shall be dug out and collected in stacks in required quantities every 50 m.

(g) *Pulverising of soils*—The soils shall then be pulverised separately with the backs of spades to such a state of fineness that about 80 per cent of the soil is under 8 mm size.

In the case of fat hard clays (P.I. over 20) the pulverization can be carried out more conveniently if the clods are wetted a day or two in advance.

(h) *Dry mixing and stacking*—The different soils in the case of base course, and soils with aggregate, in the case of wearing course shall then be mixed in the dry state by turning them over with spades and shovels. After this, stacks about 40 cm in height shall be prepared and levelled carefully on top.

(i) *Checking up of mixed stacks*—A representative sample shall be taken from the mixed stack and checked up in the field laboratory, for correctness of P.I. and sand content. Any serious departure shall be set right by adding the requisite admixture in soil.

(j) *Addition of moisture*—Optimum moisture shall be determined in the field laboratory and water required poured carefully over the stacks, small earth sides having been provided to retain the water. The water shall be added towards evening to stacks earmarked for laying next morning and allowed to soak down overnight. To ensure uniform distribution of water the stack shall be divided into a number of sub-stacks on the surface with raised earth sides.

Necessary allowance shall be made for evaporation losses and absorption by brick aggregate as determined by actual experiments from time to time. Since optimum moisture is determined on weight basis it will be necessary to determine the average weight of soil per cu m.

(k) *Laying and rolling*—After remaining in contact with moisture for several hours, the wet base course mixture shall be sliced off from the stacks in small lots, mixed as required and laid on the prepared sub-grade with the help of templates, to a cross slope of 1 in 24 for unsurfaced and 1 in 48 for surfaced road. The rolling shall be done with a 6-8 tonne flat roller, to attain a minimum dry bulk density of 1·8 gm/cu cm.

The wearing course shall also be rolled with a 6-8 tonne power roller. Rolling shall be continued till the wheels of the roller make no appreciable impression on the surface. A heavy sprinkling of water shall then be given to the road and left overnight. In the morning the surface shall again be rolled to finish.

Where stone grafting is specified the following procedure shall be adopted:

On the first day the uncompacted upper course together with the layer of stone, 25 mm gauge, spread on the surface at the rate of 2 to 2·4 cu m/100 sq m shall be rolled two to three times over the whole length and then shall be sprinkled thoroughly with water and left off till the next day.

The next day, without adding any more water the surface of the road shall be rolled thoroughly for at least 6 times. The surface shall again be thoroughly watered and left for the rest of the day.

On the third day again, the surface of the road shall be rolled after spreading some wet soil to blind the surface without any addition of water and this shall be continued

till the road is thoroughly compacted. Of these 3 days the rolling and re-rolling on the second day shall be the heaviest.

(l) *Curing*—The road shall be kept closed for traffic for 4-5 days and heavily sprinkled with water during this period. After this, water sprinkling of a lighter nature shall be continued for another 10-14 days and controlled traffic allowed to run over the road, beginning with motor traffic only and gradually extending to all kinds of traffic.

(m) *Surface treatment*—The crust shall be allowed to dry to a moisture of about 4 to 6 per cent before bituminous surfacing is given, which shall be done according to the practice prevailing in the area.

15.2.4.6 *Maintenance*—In the maintenance of this type of stabilized road all that is required is to remove the wearing course wherever a patch occurs, mix a little water and molasses (in the ratio of 3 : 1) to bring it up to near about optimum moisture and ram it back with a hand rammer. Molasses is used to give a little extra strength to the soil to make up for the facts that it is not practicable either to determine exact optimum moisture, for each patch or to cure the small patches before opening them to traffic. It has also been noticed that the slight rutting that takes place during the dry weather gets more or less smoothed out automatically under the traffic, during the wet weather. The road thus remains almost free of ruts and pot holes and the whole section wears evenly.

15.2.5 *Stabilized Soil Technique in Water Logged Areas*—Higher moisture content of the natural sub-grade soils and inadequate thickness of the road crust over it are two important factors responsible for the failure of roads under traffic in water-logged areas.

It has been observed that use of 2 per cent hydrated lime by weight of soil is quite effective as it increases soaked C.B.R. value of the worst soil from nil to more than 25 per cent.

As an alternative to lime about 1 to 2 per cent cement by weight of soil has also been used with satisfactory results but due to its higher cost the use of cement is restricted to places where lime is not readily available.

In case of soils rich in soluble sulphate 3 per cent lime by weight of soil is recommended.

Recommended thickness—In the areas of worst sub-grade moisture conditions a 35 cm to 45 cm thick sub base of natural soil stabilised with 2 per cent lime at optimum moisture with the usual 15 to 22 cm road construction above it has given satisfactory results.

15.2.6 *Soil Cement Roads*

15.2.6.1 Soil cement is the process by which soil is stabilized by the addition of cement (varying from 5 to 10 per cent by weight of soil).

It has got advantage of being economical and it also ensures that the subgrade beneath the stabilized base is not disturbed or exposed to weather and so it retains the natural stability and moisture content.

The soil for the soil-cement roads has to be properly graded; the cement content is fixed by laboratory experiments.

15.2.6.2 *Design*—Soil cement behaves as a flexible pavement and its design is based on C.B.R. value. However, as modulus of elasticity of soil cement is quite high, it can be made 25 per cent thinner than other types of flexible bases.

To counteract the effect of organic matter or acidity in soils additives like calcium chloride and lime respectively may be added. It is also possible to add rapid hardening Portland Cement instead, for it contains calcium chloride.

15.2.6.3 *Construction*—There are 2 principal methods of constructing soil cement roads suitable for rural areas:

(i) *Premix Method*—This is used when soil is imported from borrow pits.

(ii) *Mix in place method*

(a) multi-pass method

(b) Single-pass method

It is the cheapest method and permits rapid construction.

In all the above methods the soil is pulverised, mixed intimately with cement and mixture compacted at the optimum moisture content to maximum density.

The sequence of operations is as follows:

(a) Site preparation

(b) Winning the soil to be stabilised

(c) Mixing soil and cement at optimum moisture content

(d) Transportation of mixture

(e) Spreading, compacting, curing and finishing off.

(a) *Site preparation*—The top soil, etc, over the entire width of carriageway preferably for a further 30 cm on both sides is removed.

Drainage is provided to intercept water flow into sub-grade and to keep water table low. The surface drainage if provided to one side will be more economical.

Level pegs are driven to indicate finished level of soil cement base and ground shaped up to formation level. Usually a straight cross fall is preferable to a cambered section as it is easier to construct. In case some filling is required for final shaping, the same be done in layers of not more than 22 cm loose thickness and thoroughly compacted. Besides all the soft patches if any, be replaced by well compacted sound material before the soil cement base is placed.

(b) *Winning the soil*—The soil having been tested is excavated by the most suitable equipment and stock piled near the mixing plant. The plant is located near the source of supply or road site as per circumstances.

(c) *Mixing*—The mixing of the soil and cement must be thorough and at a controlled moisture content. The materials can be batched by weight or volume. In a well organised set up weigh batching will be more efficient. Cement should never be batched by volume.

(d) *Transportation*—The essential feature of transporting the mixed material from the mixing plant to the site is to ensure that it is done quickly. For ordinary portland cement not more than 30 minutes should elapse between the time the material leaves the mixer and the compacting operation begins. In case of rapid hardening cement, this should not exceed 20 minutes.

(e) *Spreading, Compaction and Finishing*—The soil cement should be spread by hand in layers not exceeding 22 cm.

For cohesive and granular soils a multi-wheel pneumatic roller followed by smooth wheeled roller of 8 to 10 tonnes is used for compaction.

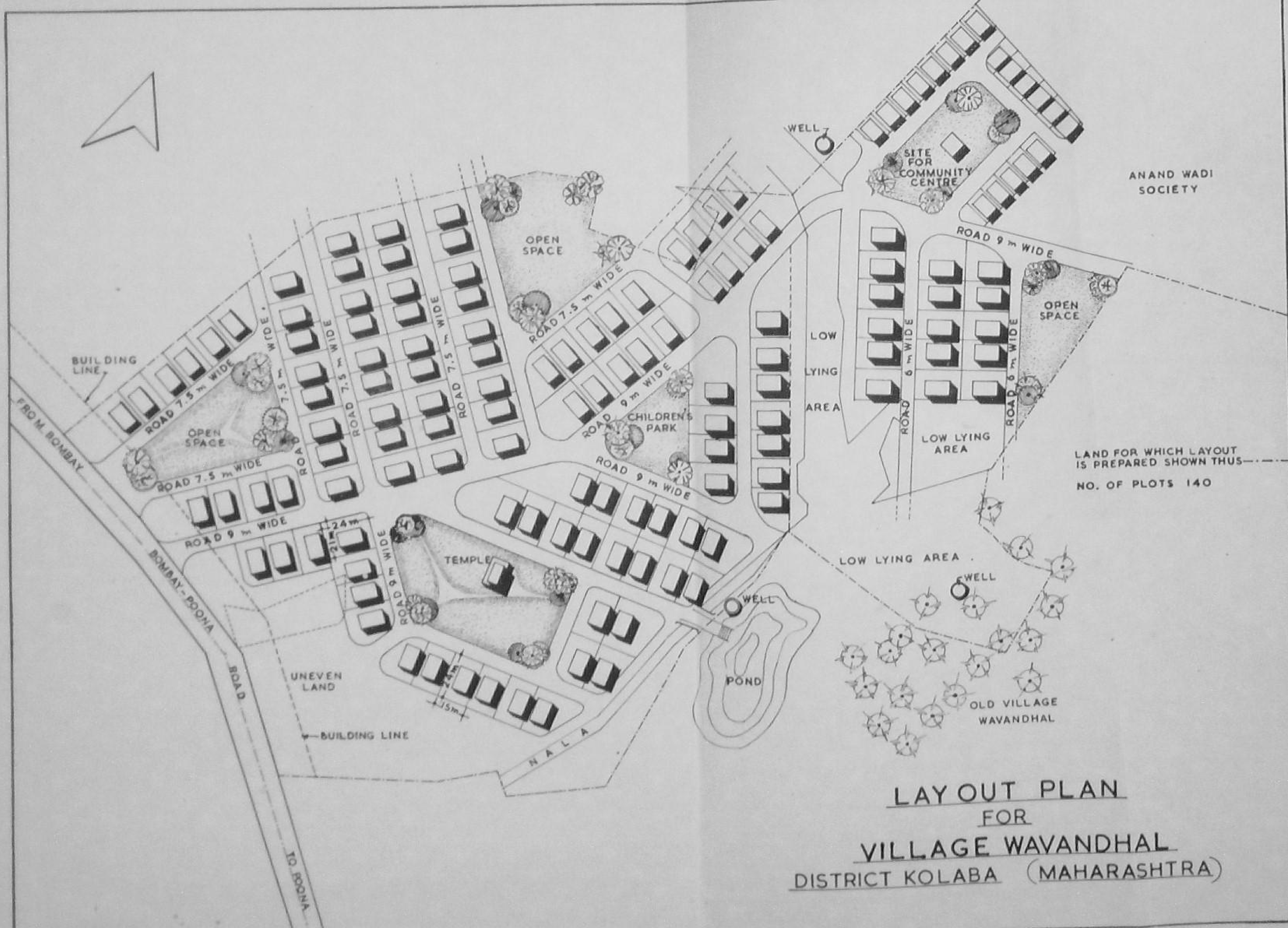
Compacting rollers should start on the lower side and work towards the high side and should continue till it shows no yield under roller. Watering of wheels of roller is forbidden; tendency towards picking up can be overcome by dusting the rollers with cement or lime stoneflour.

The finished surface should be true to line and level.

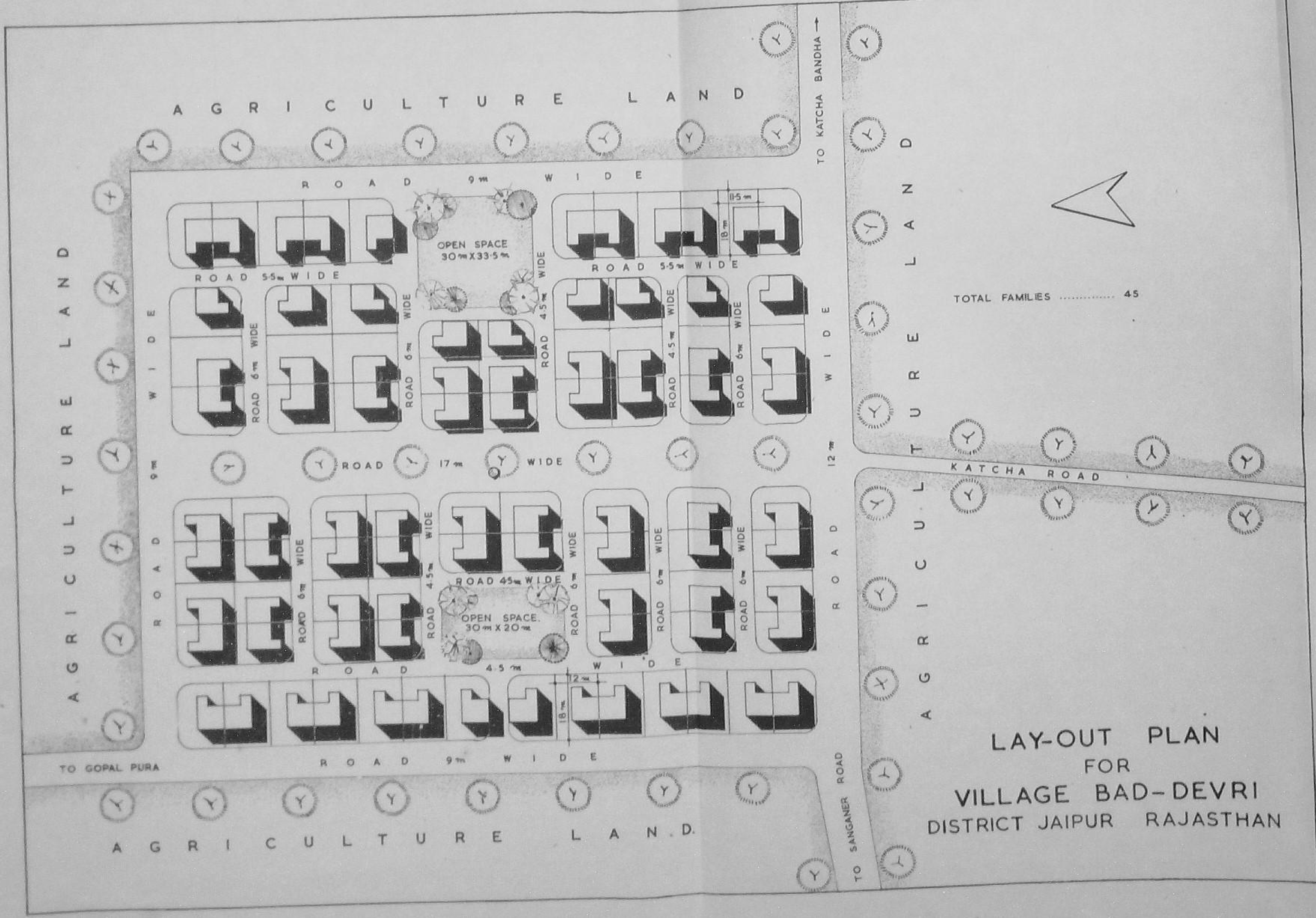
For curing, any of the conventional methods used for curing concrete roads may be used. It is however, usual with soil cement to give the surface a dressing of bitumen emulsion This not only cures soil cement but also acts as a tack coat for any bituminous carpet subsequently superimposed on it.

15.2.6.4 *Joints*—The work should be so organised that wherever possible the area processed should cover full width of carriage way so that longitudinal joints against hardened soil cement be avoided.

Transverse joints should be at right angles to the centre line of the road and should be cutback to a vertical face. The junction of subsequent work to this should be a vertical butt joint, no attempt being made to marry the new work to old. A gap may be left between the two, to be subsequently filled in with pre-mixed soil cement compacted by rammers.

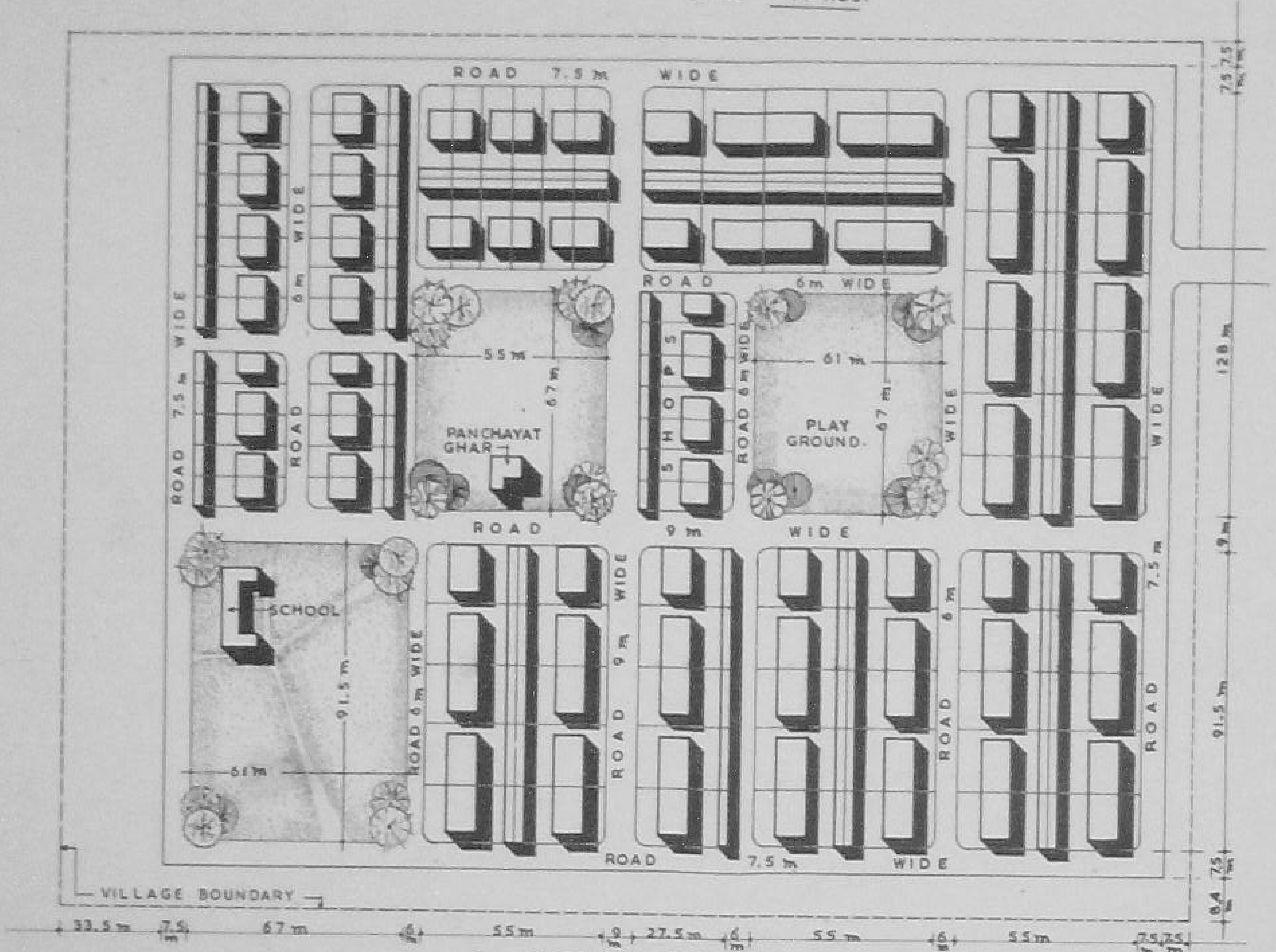


LAYOUT PLAN FOR VILLAGE WAVANDHAL DISTRICT KOLABA (MAHARASHTRA)

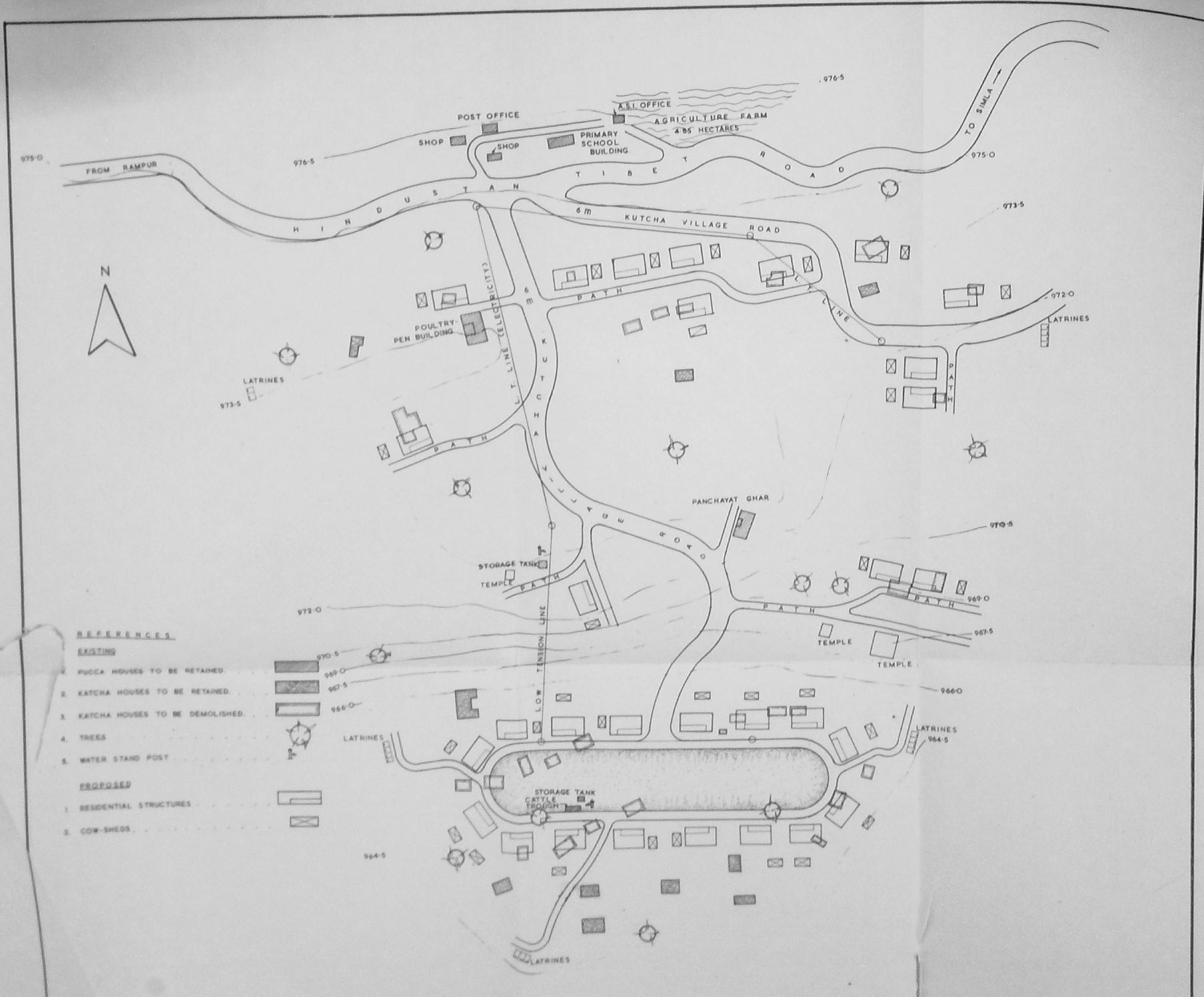


LAY-OUT PLAN
FOR
VILLAGE BAD-DEVRI
DISTRICT JAIPUR RAJASTHAN

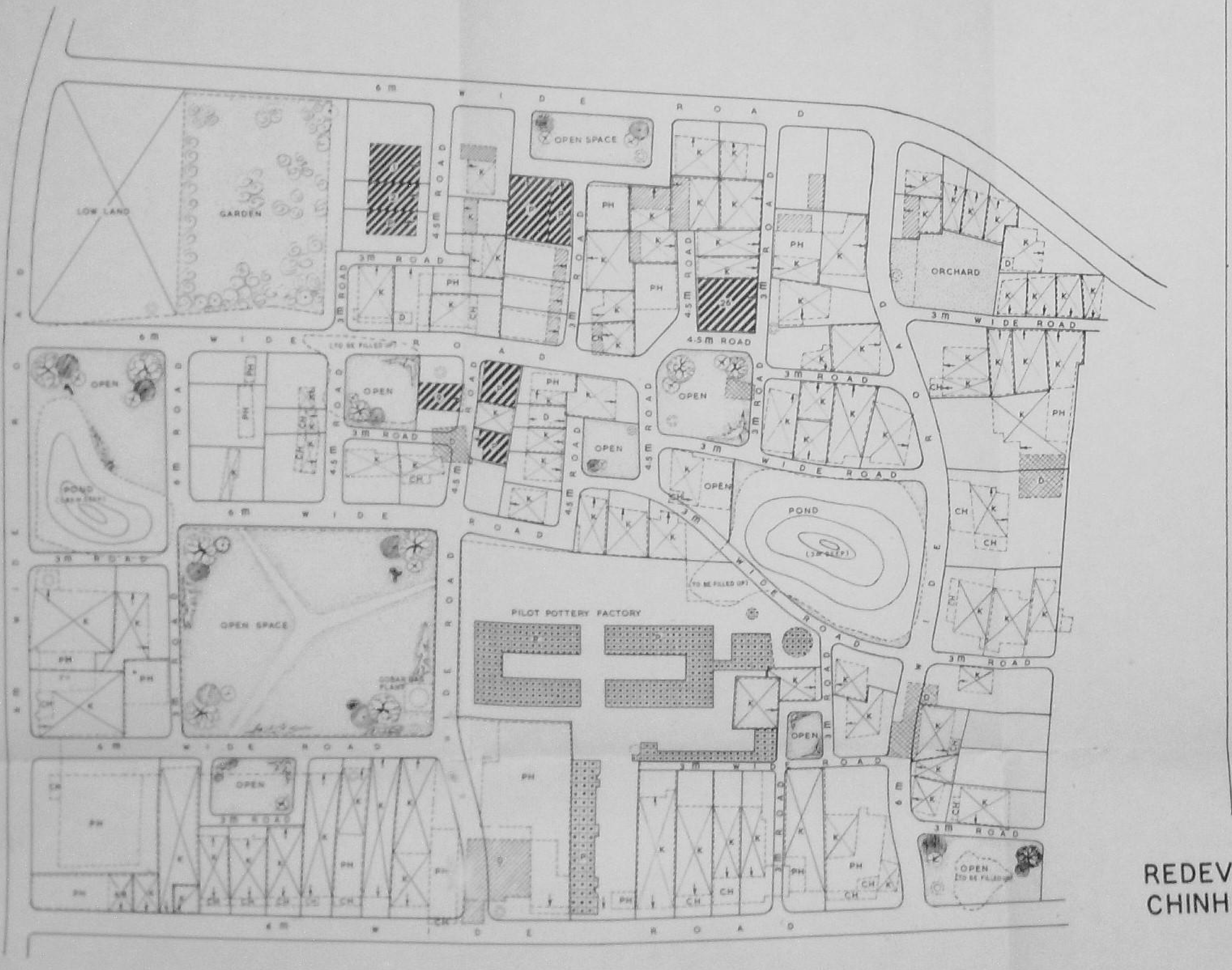
HOUSE PLOTS (18 m X 27 m EACH) 59 NOS.
HOUSE PLOTS (9 m X 27 m EACH) 38 NOS.
TOTAL 97 NOS.

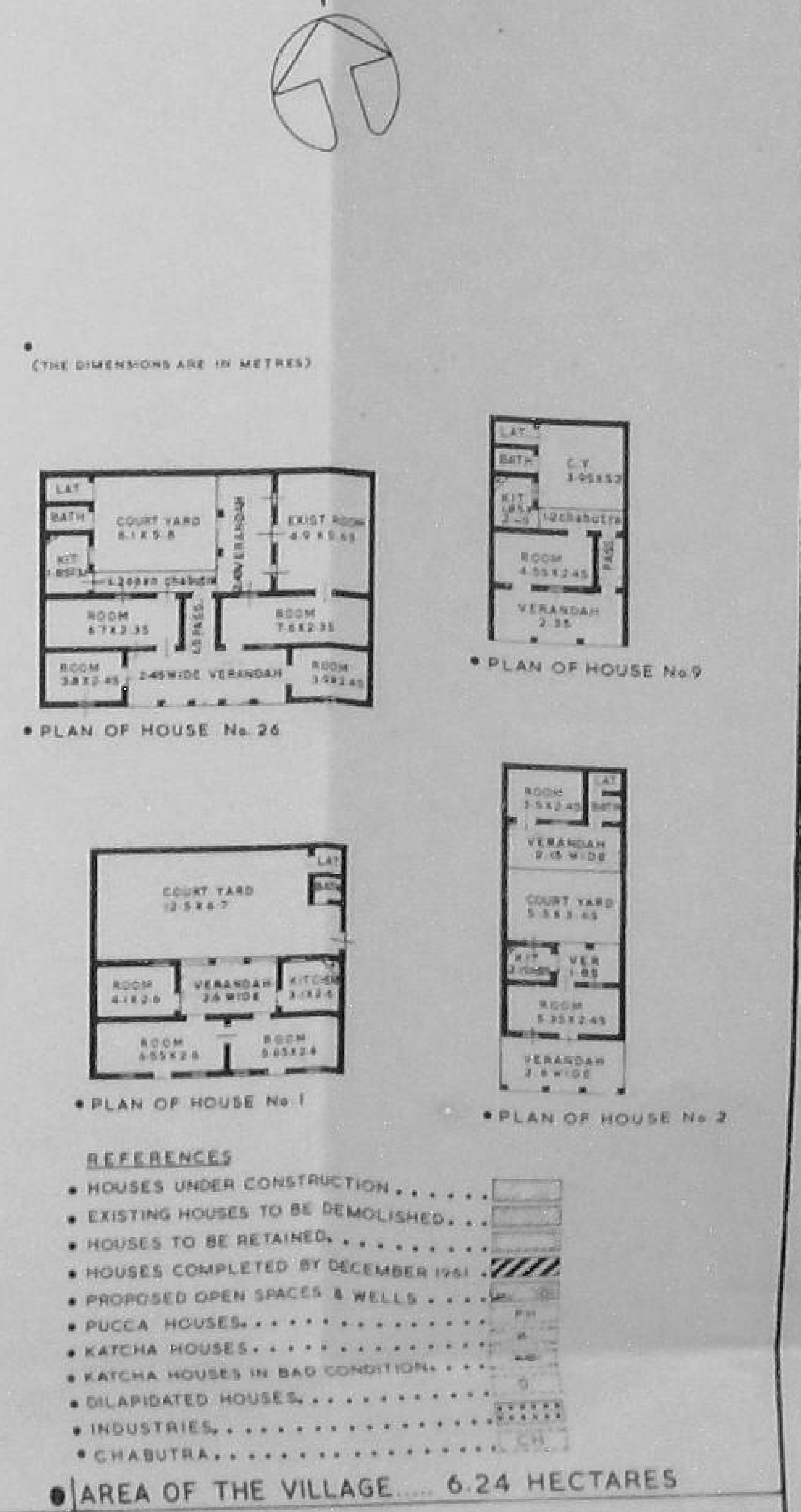


LAYOUT PLAN
VILLAGE TANTHAL
DISTT. PATIALA (PUNJAB)

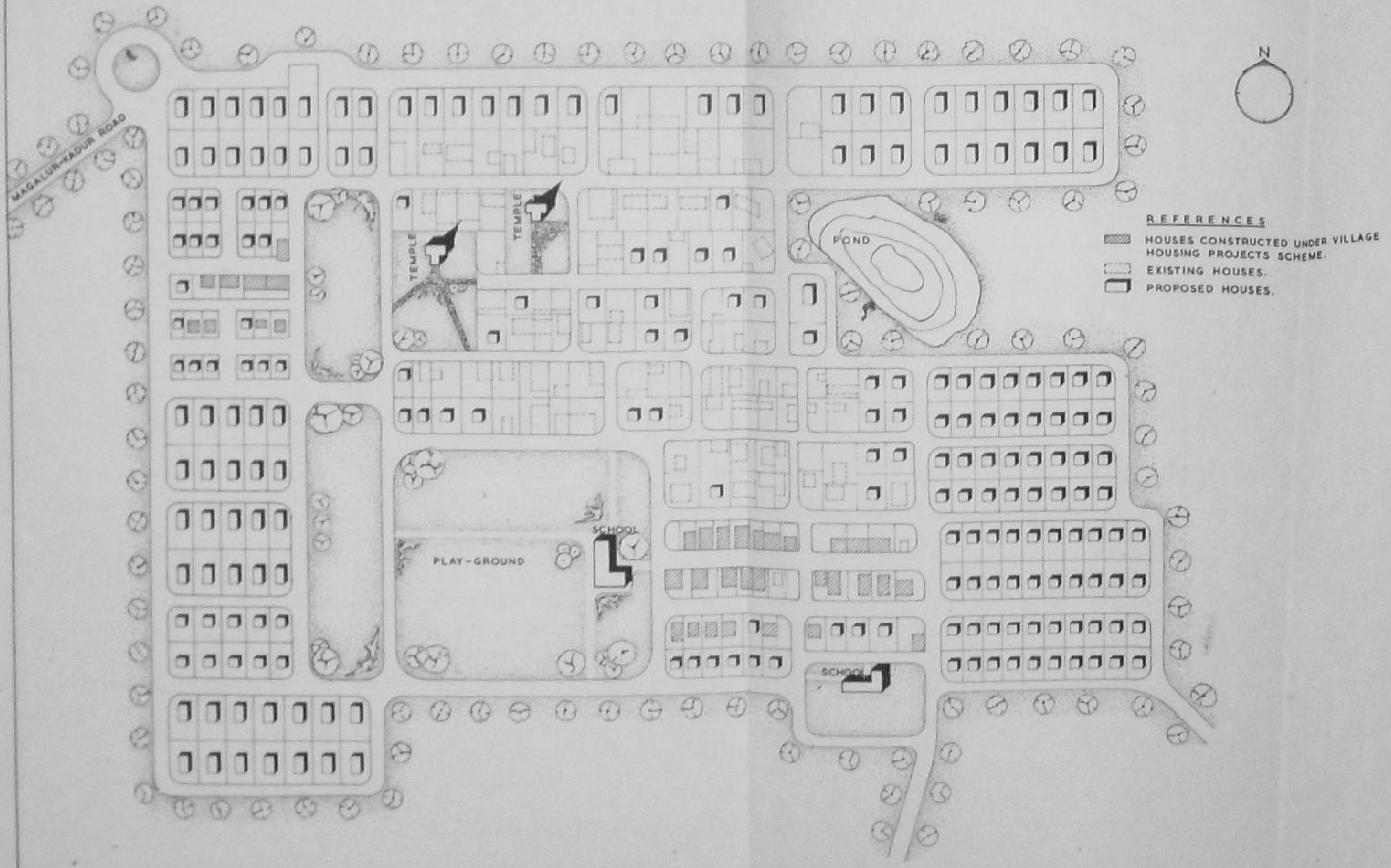


TO SIMLA
976·5
A.S.I. OFFICE
AGRICULTURE FARM
4·85 HECTARES
POST OFFICE
SHOP
SHOP
PRIMARY SCHOOL BUILDING
975·0
FROM RAMPUR
976·5
HINDUSTAN TIBET ROAD
975·0
973·5
6 m KUTCHA VILLAGE ROAD
N
PATH
L.T. LINE
972·0
LATRINES
POULTRY-PEN BUILDING
L.T. LINE (ELECTRICITY)
6 m KUTCHA VILLAGE ROAD
LATRINES
973·5
PATH
PATH
PANCHAYAT GHAR
970·5
STORAGE TANK
TEMPLE
PATH
969·0
972·0
PATH
967·5
TEMPLE
TEMPLE
970·5
969·0
967·5
966·0
966·0
LOW TENSION LINE
LATRINES
LATRINES
964·5
STORAGE TANK
CATTLE TROUGH
964·5
LATRINES
REFERENCES
EXISTING
1. PUCCA HOUSES TO BE RETAINED
2. KATCHA HOUSES TO BE RETAINED
3. KATCHA HOUSES TO BE DEMOLISHED
4. TREES
5. WATER STAND POST
PROPOSED
1. RESIDENTIAL STRUCTURES
2. COW-SHEDS





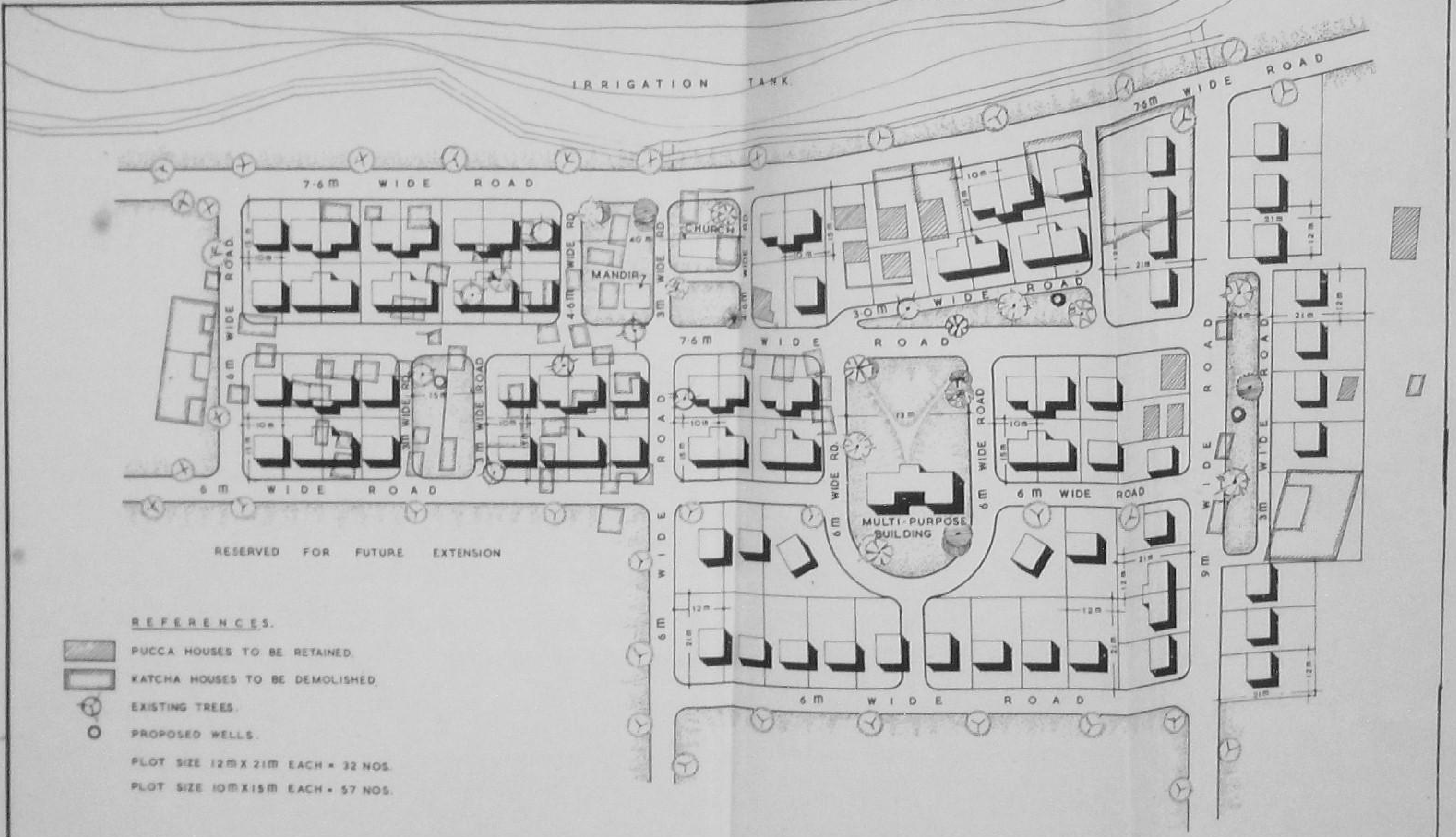
REDEVELOPMENT PLAN OF VILLAGE CHINHAT, DISTT. LUCKNOW, U.P.



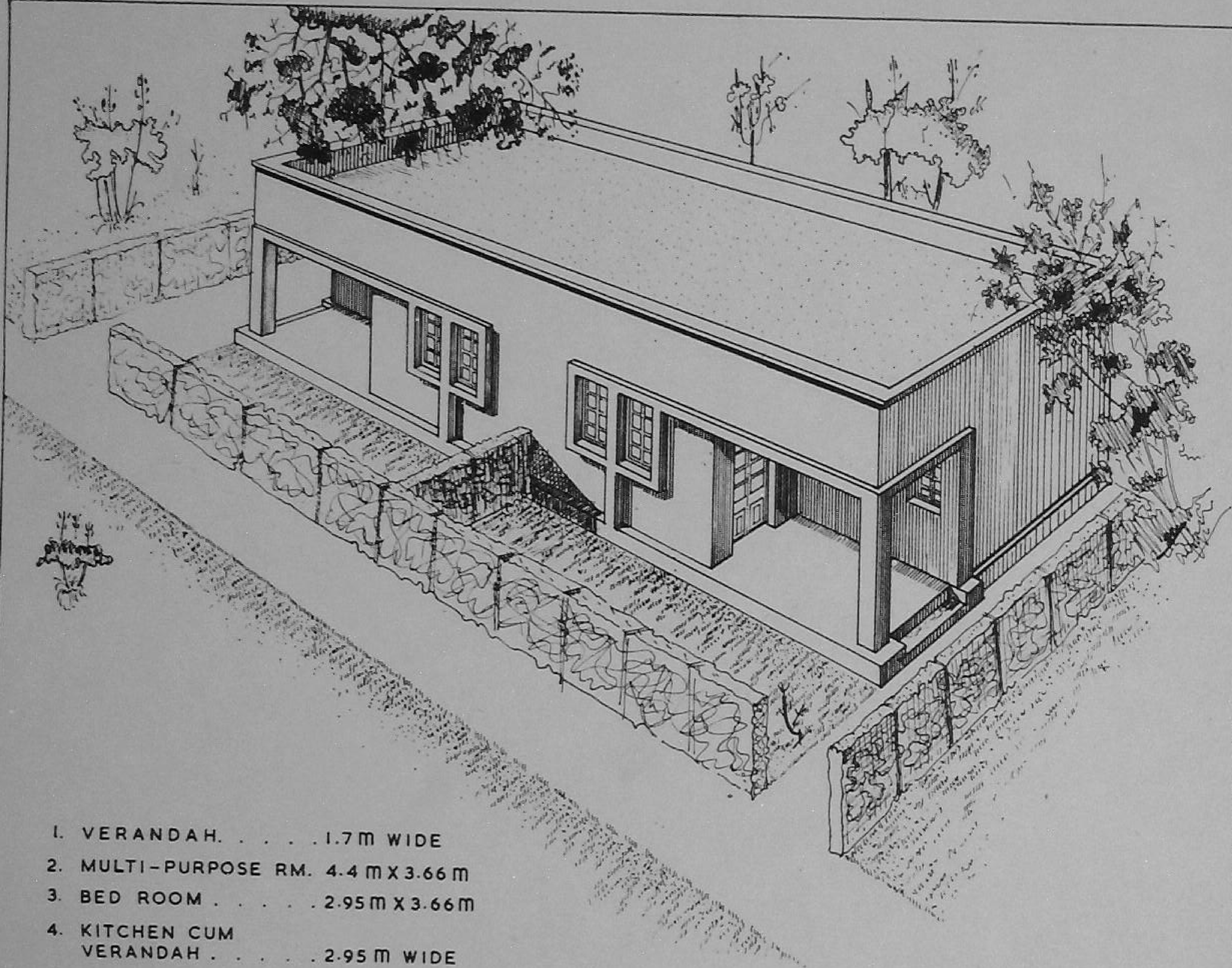
DEVELOPMENT PLAN FOR VILLAGE HIREGOUJA

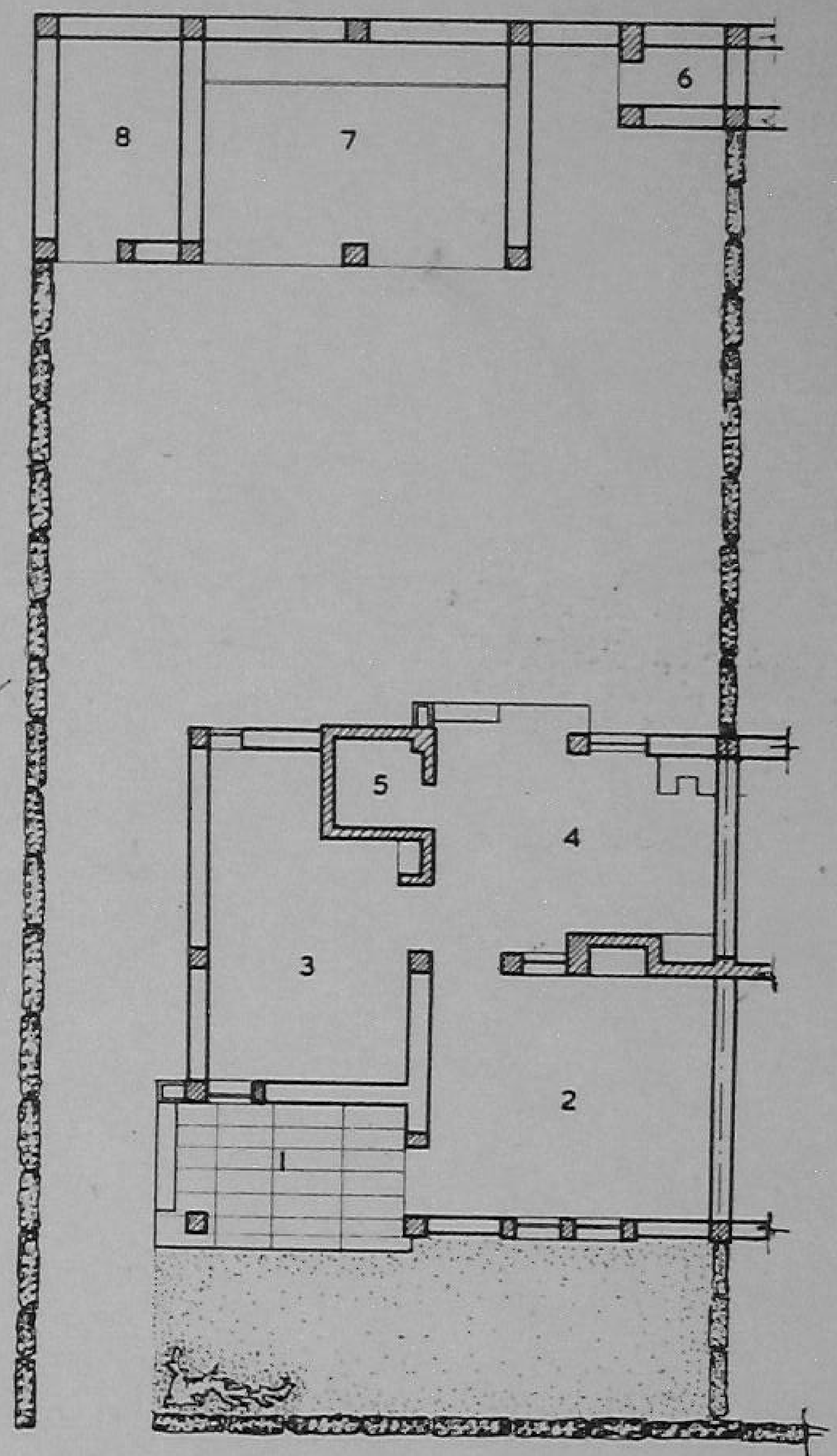
CHIKAMAGALUR BLOCK (MYSORE)

DEVELOPMENT PLAN OF VILLAGE BORSUL, DISTRICT BURDWAN, WEST BENGAL.



LAY-OUT PLAN FOR VILLAGE MUPPAVARAM
WEST GODAVERY, ANDHRA PRADESH.



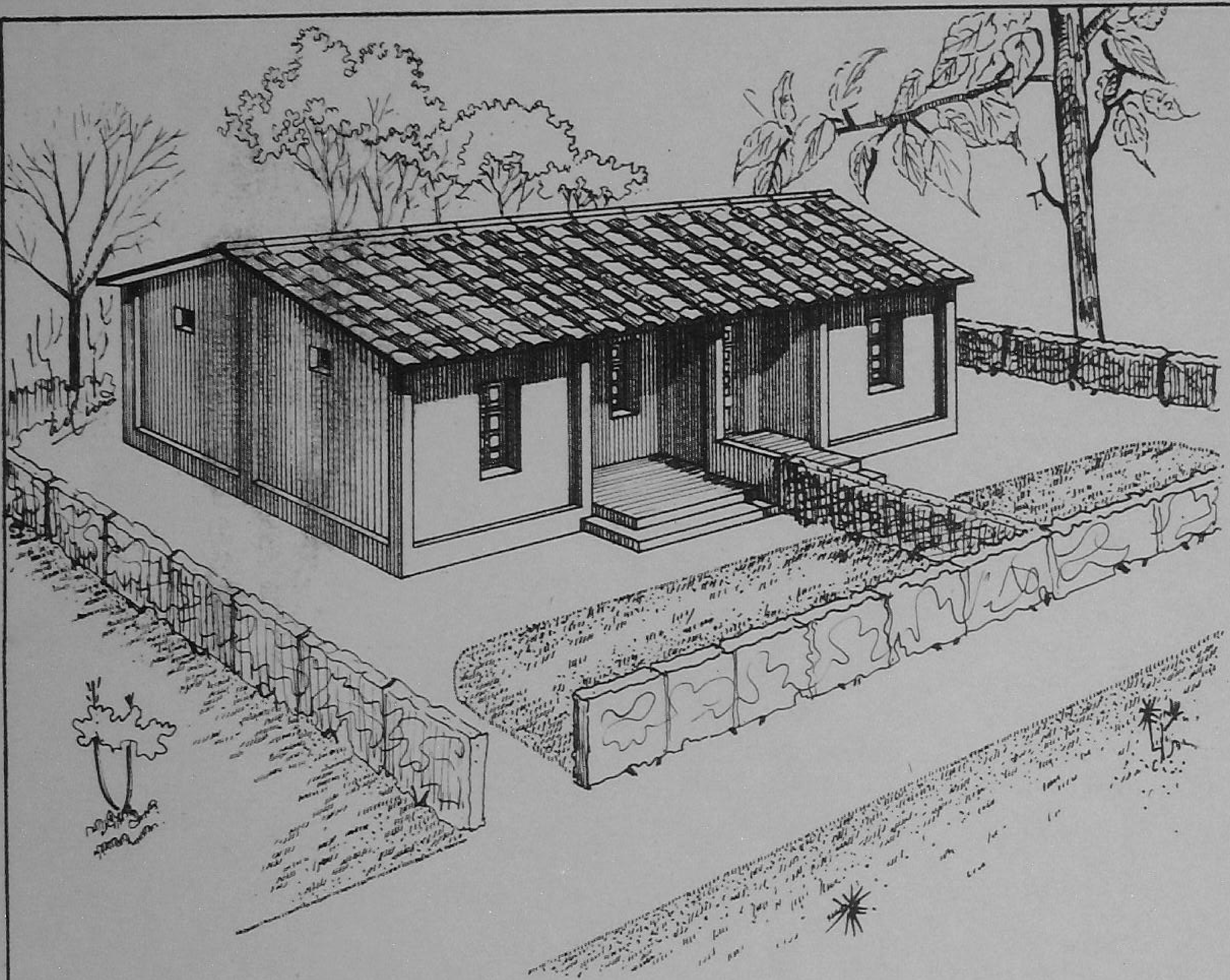


PLAN

1. VERANDAH. . . . . 1.7 m WIDE
2. MULTI-PURPOSE RM. 4.4 m X 3.66 m
3. BED ROOM . . . . . 2.95 m X 3.66 m
4. KITCHEN CUM VERANDAH . . . . . 2.95 m WIDE
5. BATH RM. . . . . . 1.35 m X 1.4 m
6. LATRINE . . . . . . 1.22 m X 0.9 m
7. CATTLE SHED . . . 4.6 m X 3.0 m
8. FODDER STORE. . . 1.83 m X 3.0 m

TWO ROOMED DEMONSTRATION HOUSE

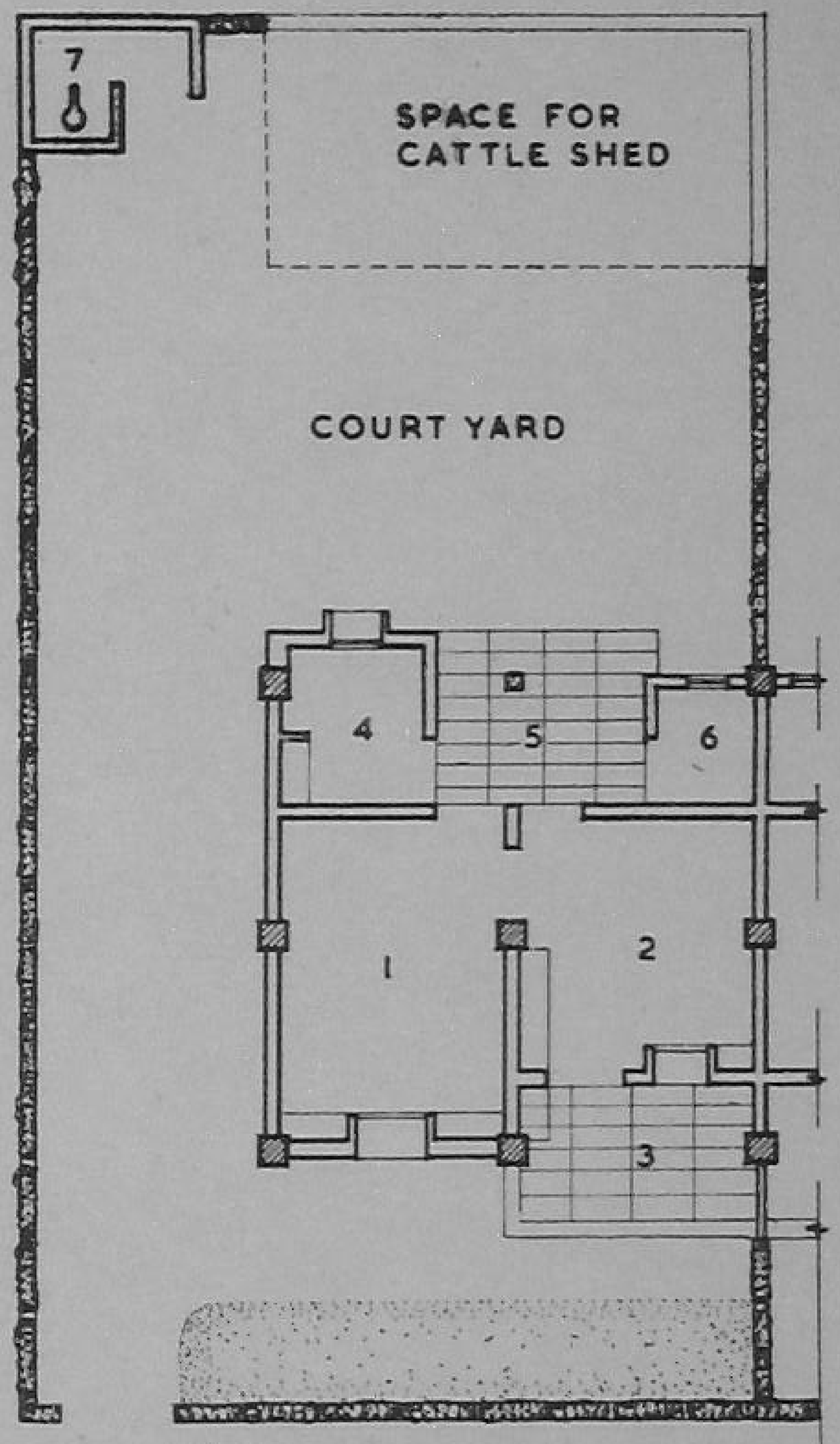
RURAL HOUSING WING, CHANDIGARH. (PUNJAB)



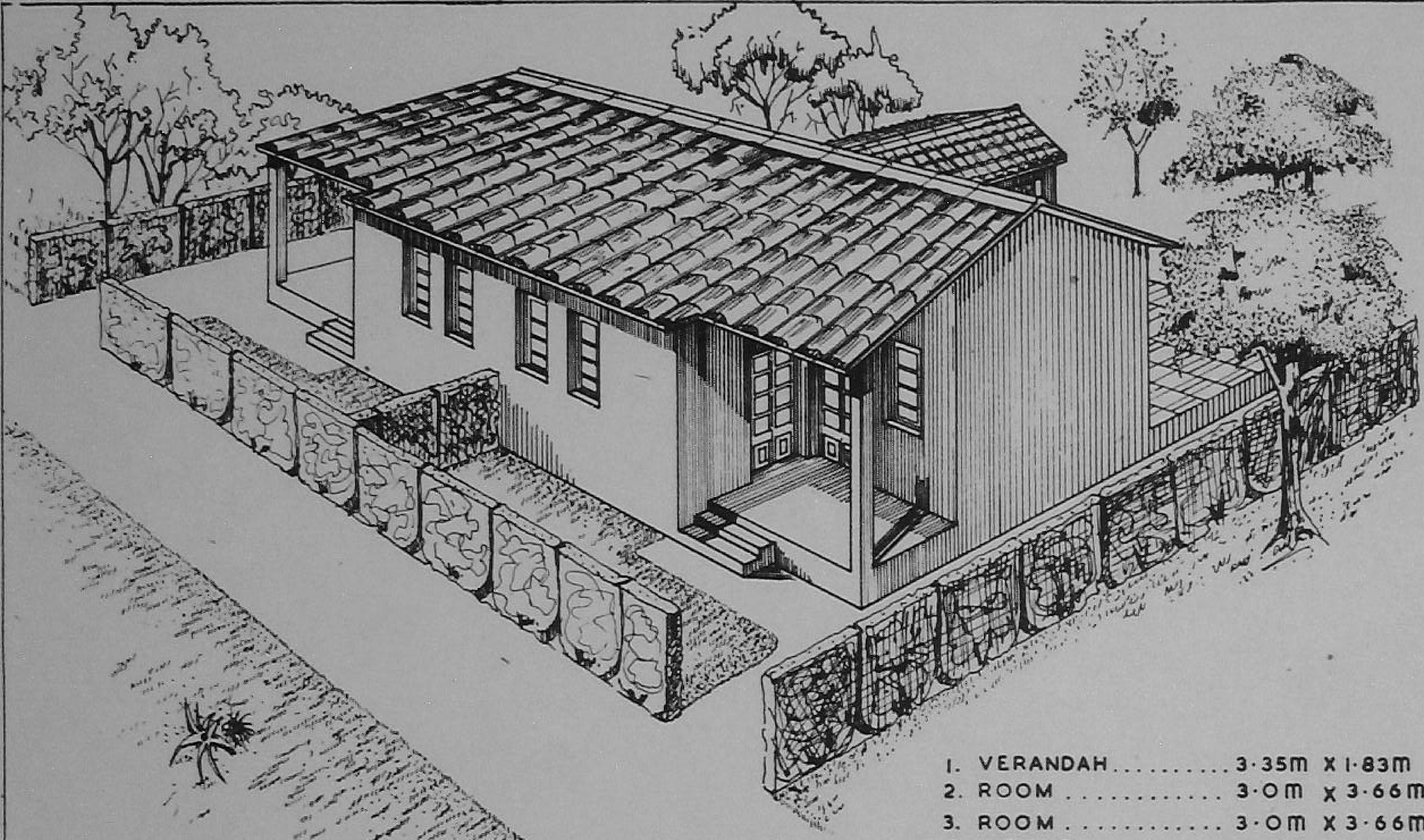
TWO ROOMED DEMONSTRATION HOUSE

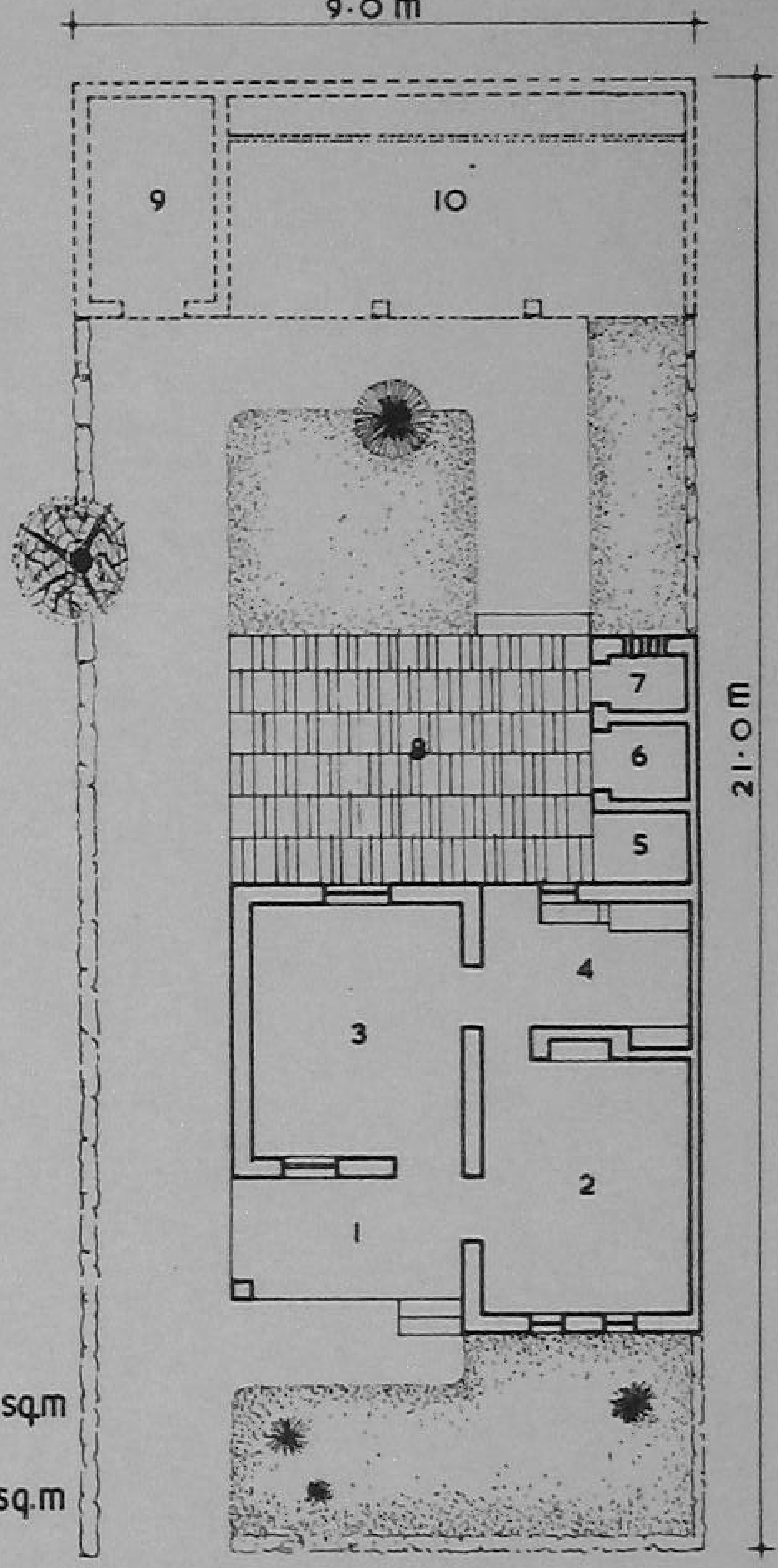
RURAL HOUSING WING, ROORKEE. (U.P.)

1. ROOM . . . . 2.8 m X 3.95 m
2. ROOM . . . . 2.95 m X 3.0 m
3. VERANDAH . . . . 1.75 m WIDE
4. KITCHEN . . . . . . 1.9 m X 2.0 m
5. REAR VERANDAH . 2.3 m WIDE
6. BATH . . . . 1.5 m X 1.2 m
7. LATRINE . . . . . . 1.35 m X 0.9 m



PLAN





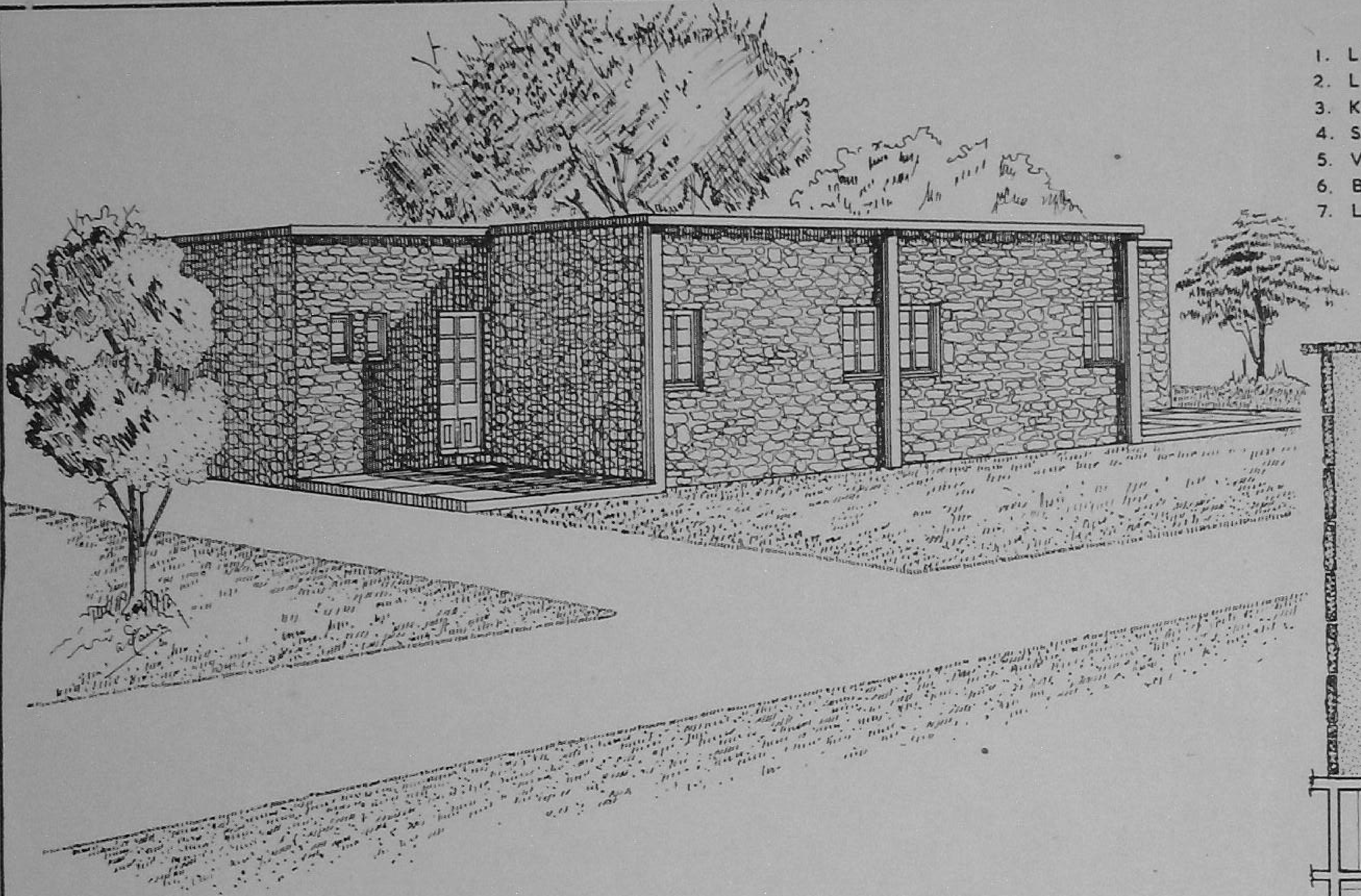
PLAN

1. VERANDAH .... 3·35m X 1·83m
2. ROOM .... 3·0m X 3·66m
3. ROOM .... 3·0m X 3·66m
4. KITCHEN .... 3·0m X 1·83m
5. STORE .... 1·37m X 1·0m
6. BATH .... 1·0m X 1·0m
7. LATRINE .... 1·0m X 0·9m
8. PLATFORM .... 6·7m X 3·66m
9. FODDER STORE .... 1·83m X 3·0m
10. CATTLE SHED .... 6·7m X 3·0m

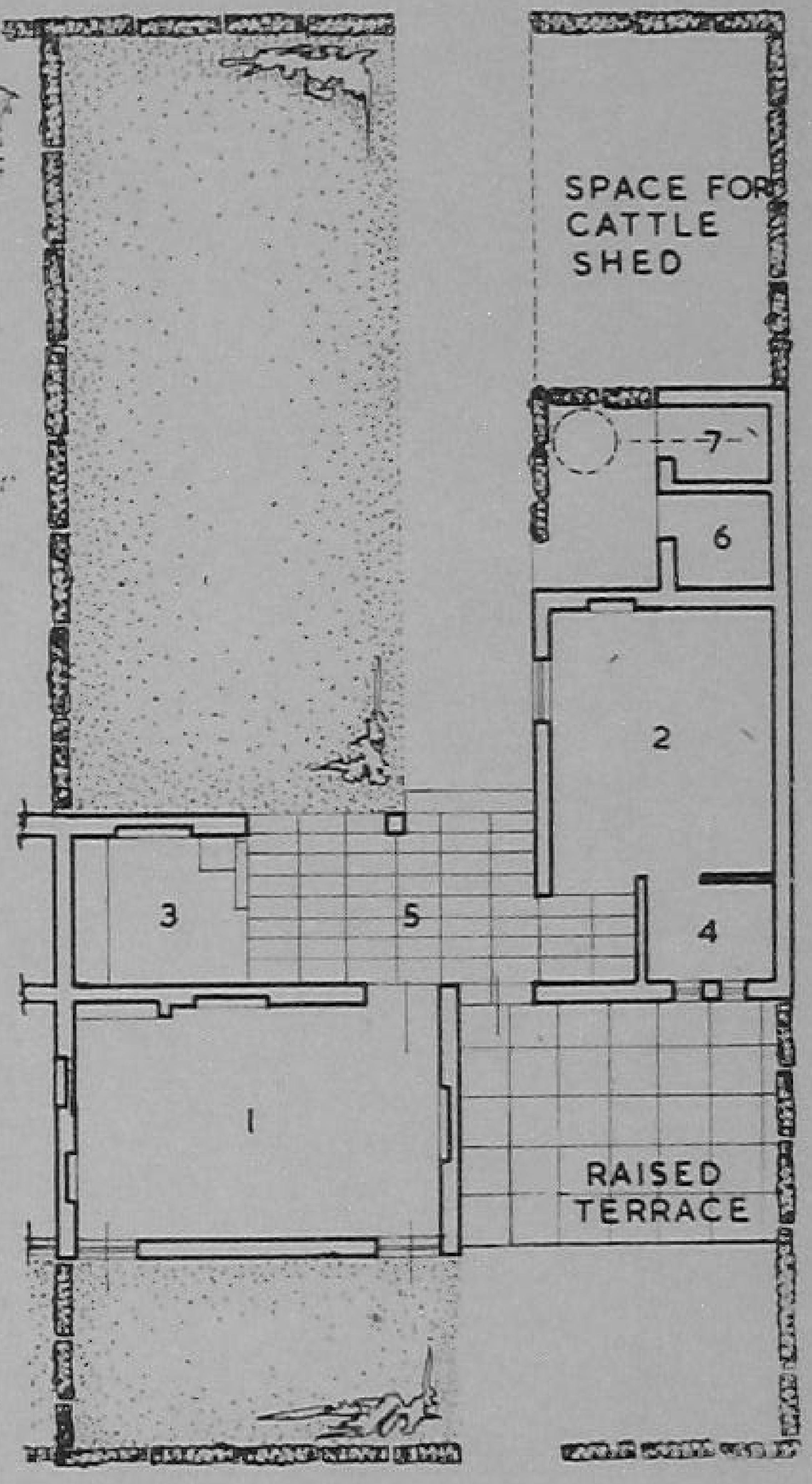
- PLINTH AREA OF THE HOUSE. 49·32 sq.m
- PLINTH AREA OF CATTLE SHED 32·0 sq.m

TWO ROOMED DEMONSTRATION HOUSE,

RURAL HOUSING WING, VALLABH VIDYANAGAR. (GUJARAT)



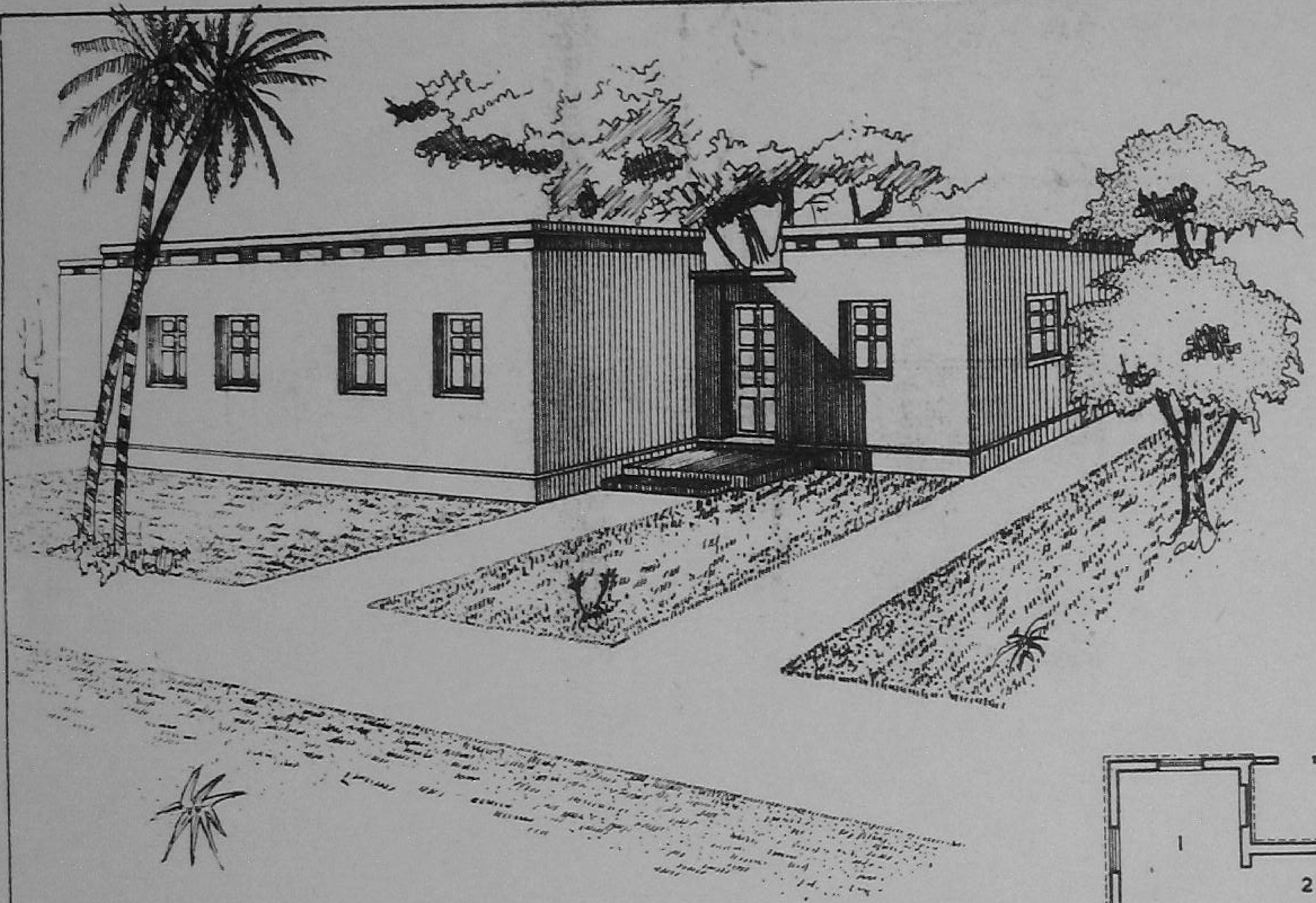
1.	LIVING ROOM	4.6 m X 2.8 m
2.	LIVING ROOM	2.7 m X 3.3 m
3.	KITCHEN	1.9 m X 1.8 m
4.	STORE	1.6 m X 1.2 m
5.	VERANDAH	2.1 m WIDE
6.	BATH	1.2 m X 1.2 m
7.	LATRINE	1.2 m X 0.9 m



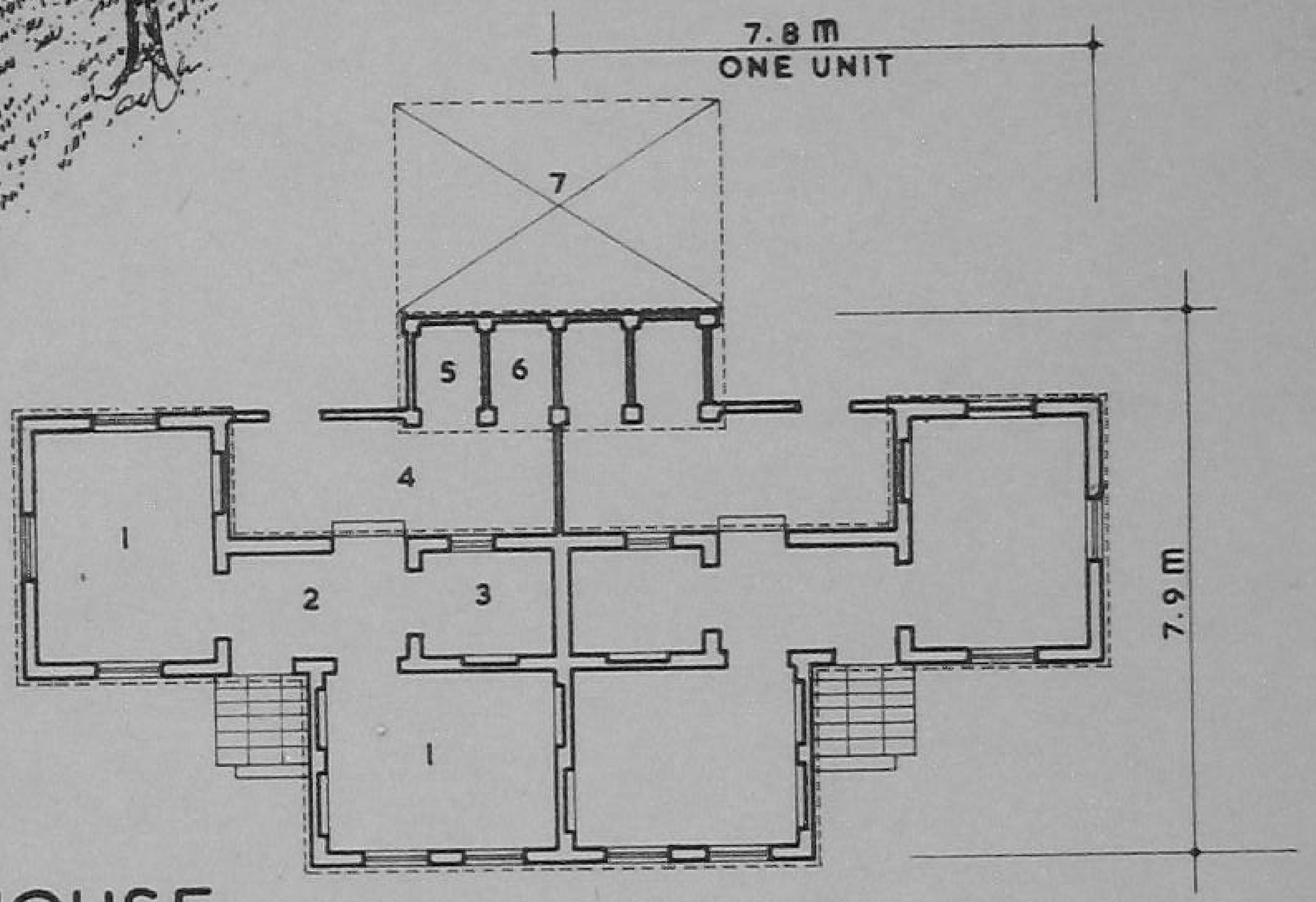
PLAN

TWO ROOMED DEMONSTRATION HOUSE

RURAL HOUSING WING – DELHI.



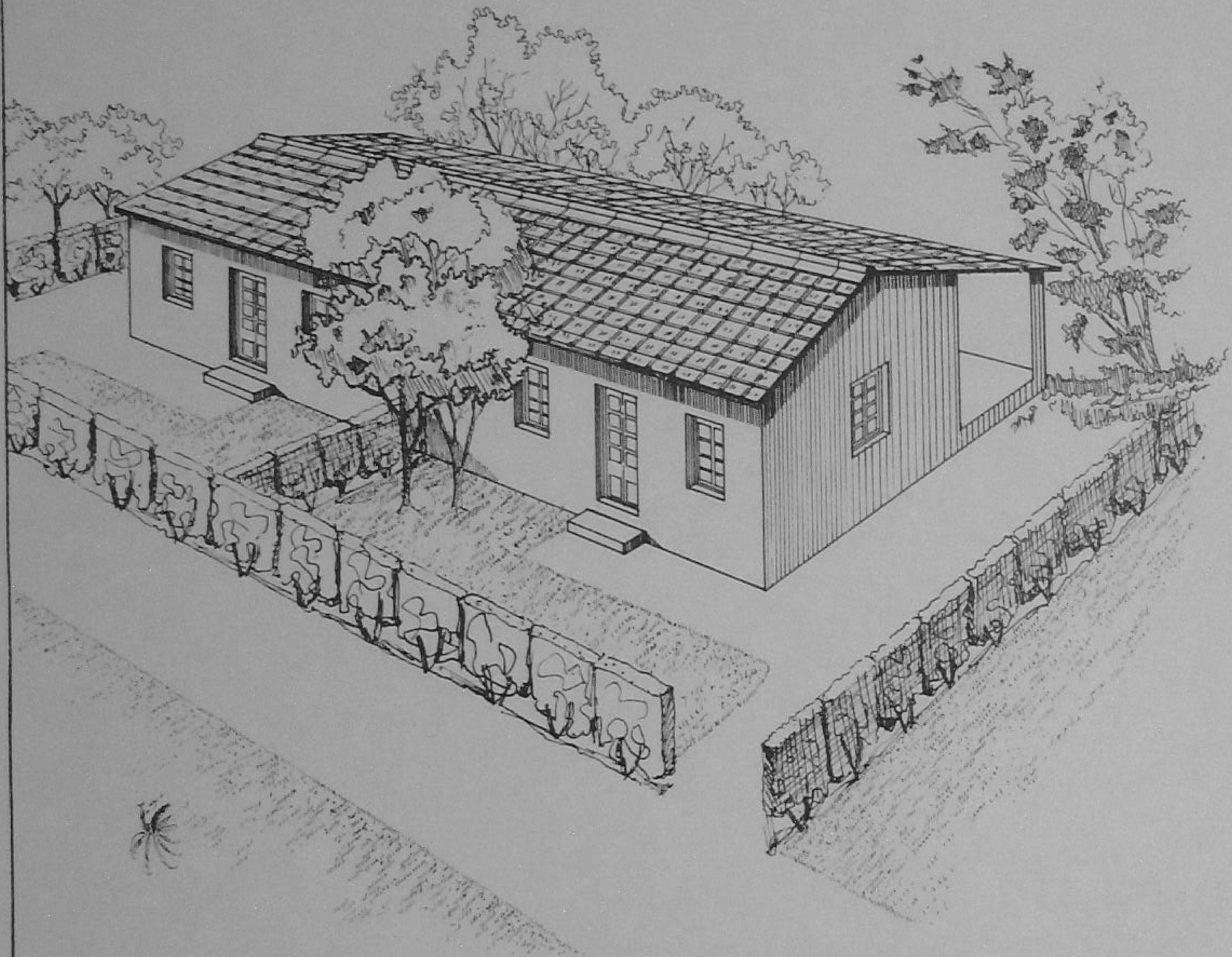
1. BED ROOM . . . . . 3.0m x 2.5m
2. VERANDAH . . . . . 2.6m x 1.5m
3. KITCHEN . . . . . . 1.9m x 1.5m
4. OPEN COURT YARD . . 4.8m x 1.7m
5. BATH . . . . 0.9m x 1.22m
6. LATRINE . . . . . . 0.9m x 1.22m
7. SPACE FOR CATTLE SHED . . . . 4.25m x 3.0m



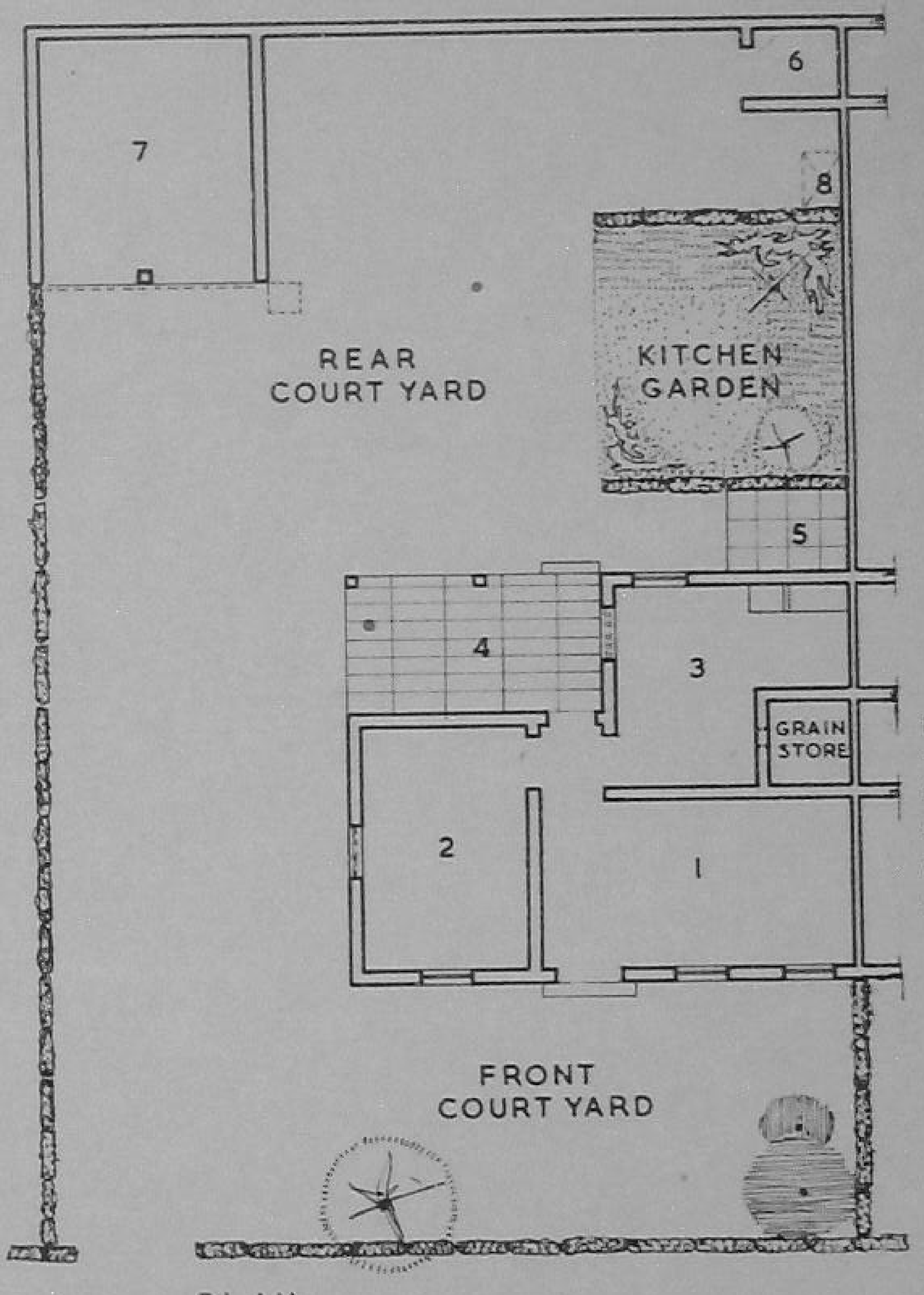
PLAN

TWO ROOMED DEMONSTRATION HOUSE

RURAL HOUSING WING, CALCUTTA. (WEST BENGAL)



1. ROOM . . . . 4.6 m X 2.44 m
2. ROOM . . . . 2.44 m X 3.66 m
3. KITCHEN CUM DINING AND GRAIN-STORE . . . 3.2 m X 3.0 m
4. VERANDAH. . . . . . . 2.0 m WIDE
5. WASHING PLATFORM. . 1.83 m X 1.22 m
6. LATRINE . . . . 1.22 m X 1.0 m
7. CATTLE SHED . . . . . 3.1 m X 3.66 m
8. SEPTIC TANK. . . . . . 0.6 m X 0.75 m

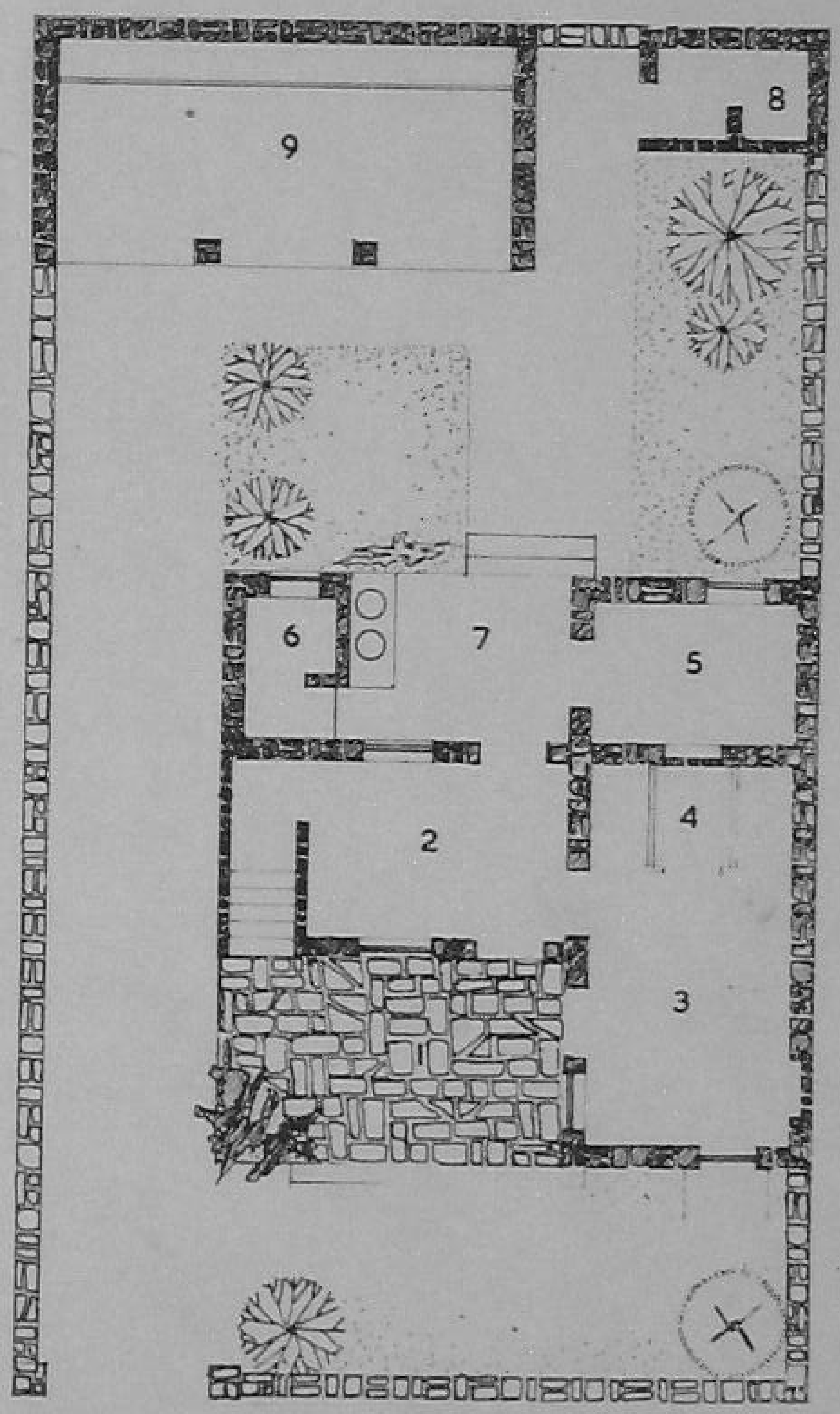


PLAN

TWO ROOMED DEMONSTRATION HOUSE

RURAL HOUSING WING, BANGALORE. (MYSORE)

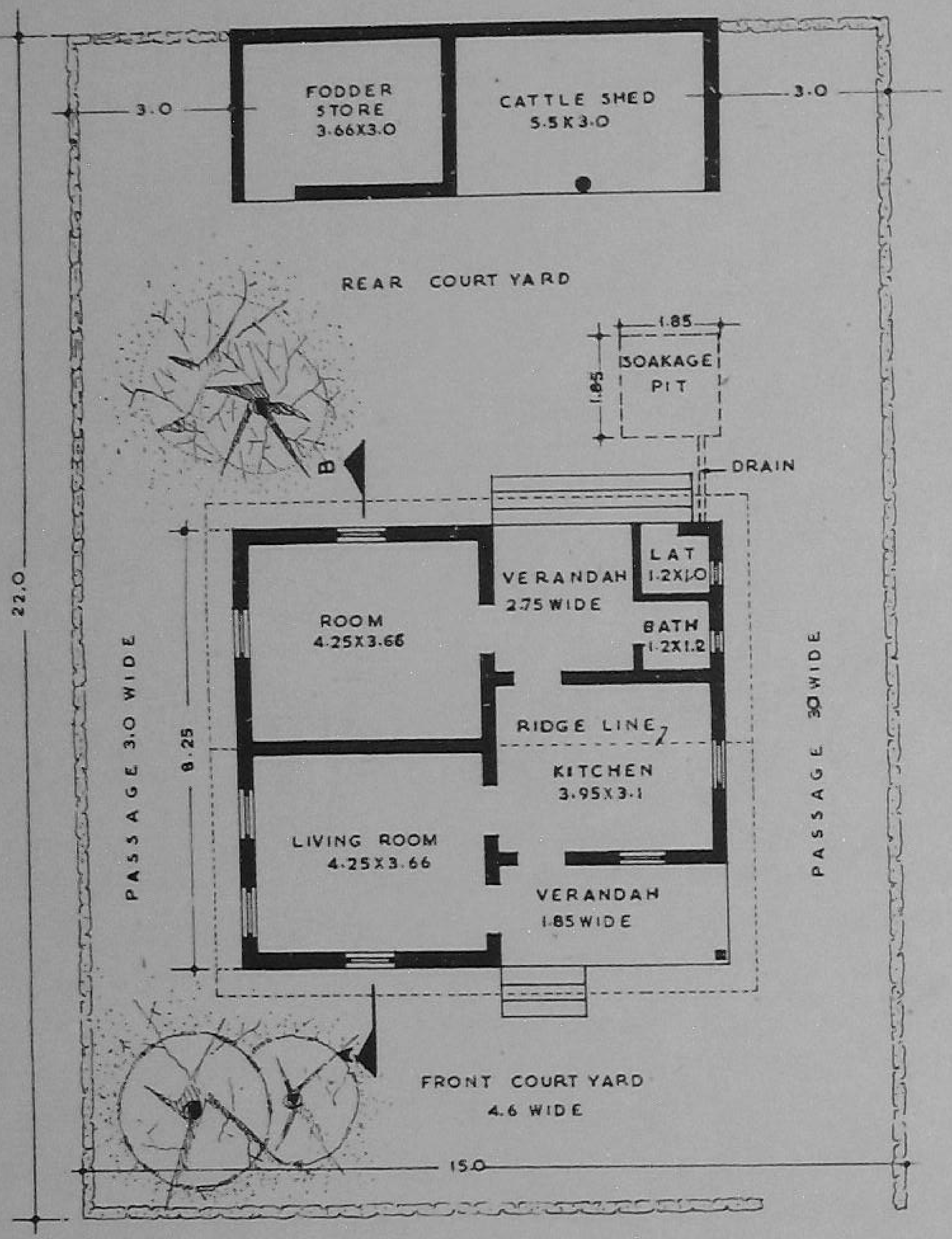
TWO ROOMED HOUSE – RAJASTHAN



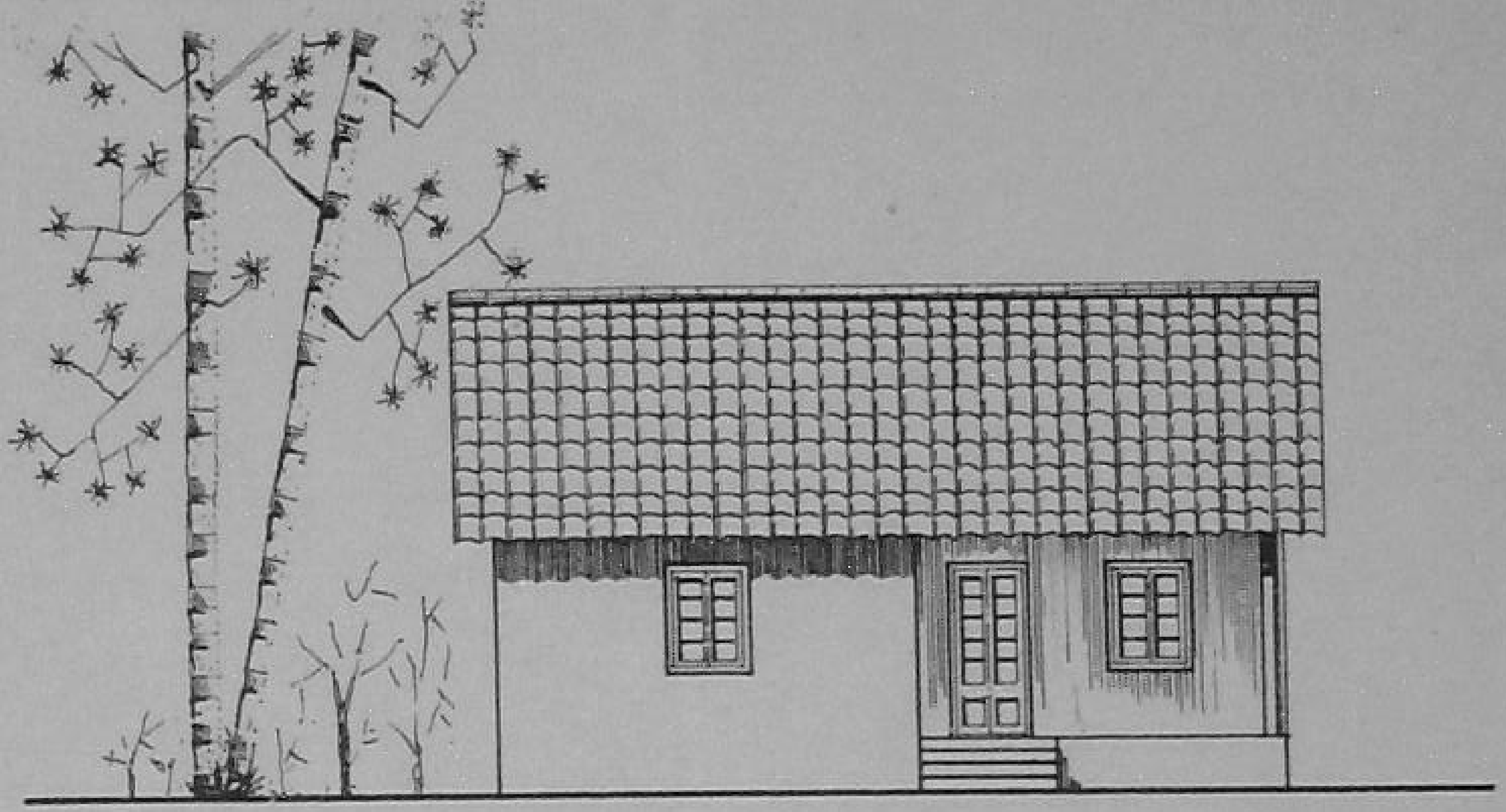
PLAN

1. PLATFORM . . . . . 4.6 m x 2.75 m
2. ROOM . . . . 3.66 m x 2.44 m
3. ROOM . . . . 3.66 m x 2.75 m
4. GRAIN STORE . . . 2.75 m x 1.35 m
5. KITCHEN . . . . . . 2.75 m x 1.83 m
6. BATH . . . . 1.22 m x 1.0 m
7. VERANDAH . . . . 2.15 m WIDE
8. LATRINE . . . . . . 0.9 m x 1.22 m
9. CATTLE SHED . . . 6.0 m x 3.0 m

- PLINTH AREA OF THE HOUSE . . . . 51.0 sq.m
- PLINTH AREA OF CATTLE SHED . . . 20.9 sq.m

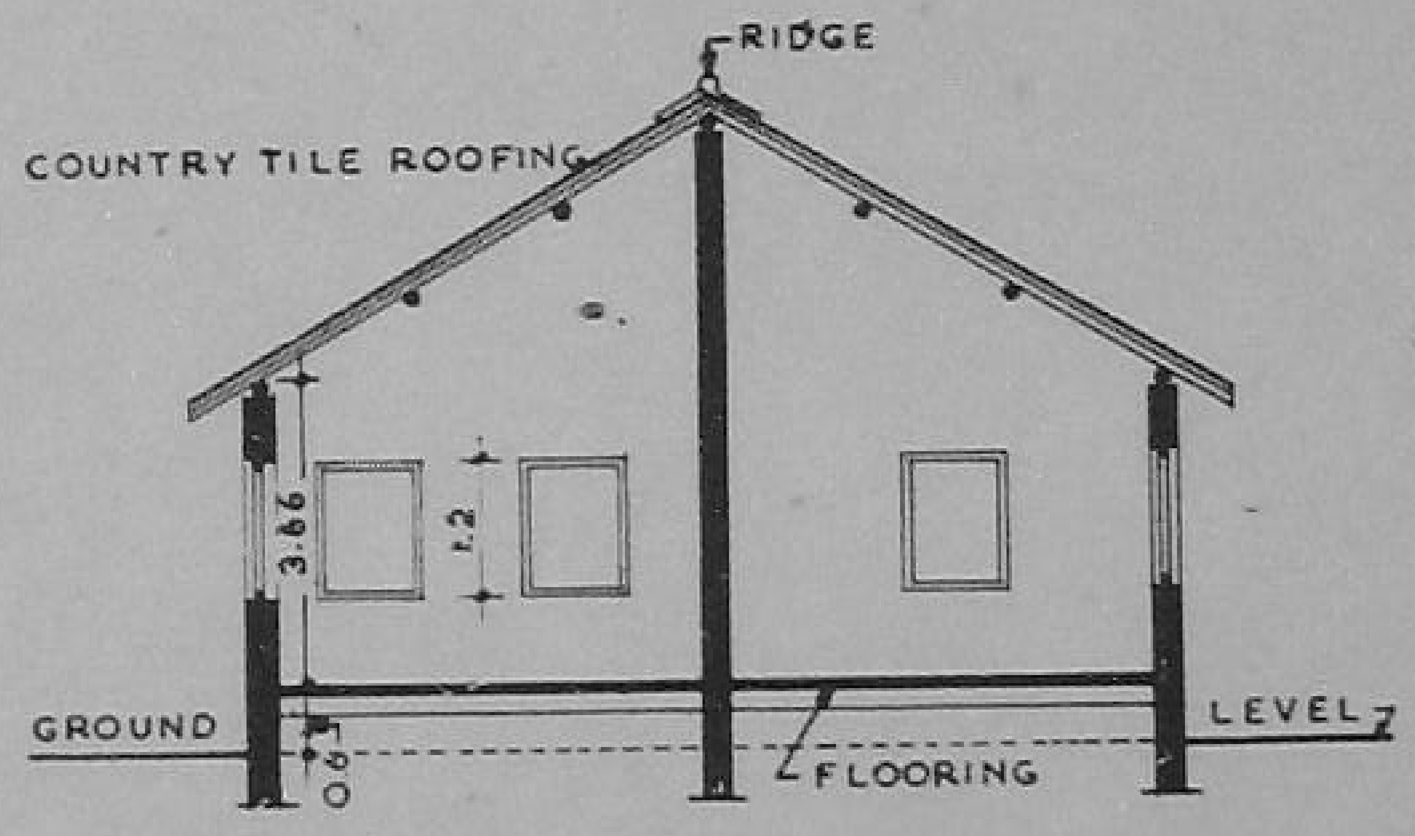


PLAN



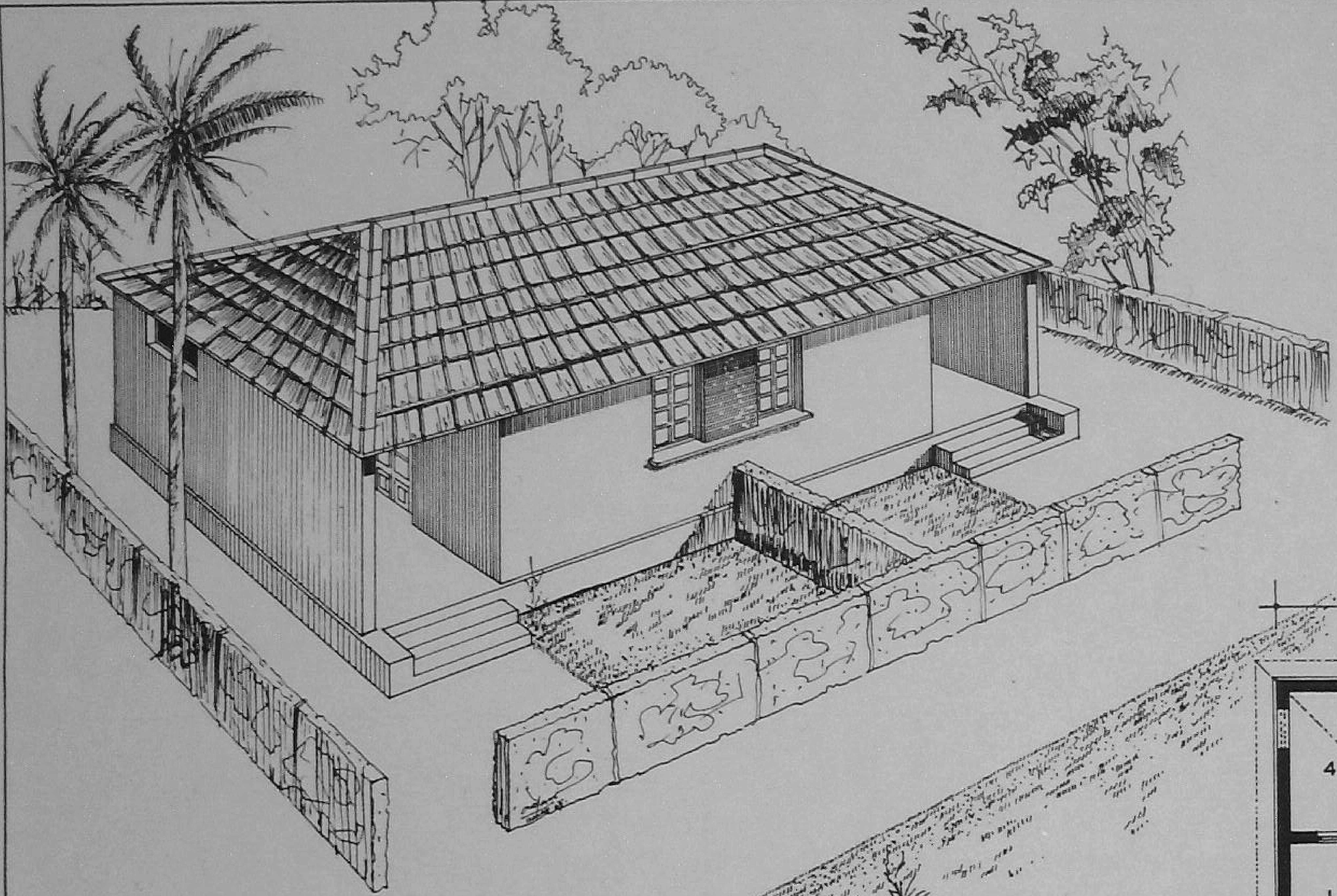
FRONT ELEVATION

• NOTE
THE DIMENSIONS ARE IN METRES.



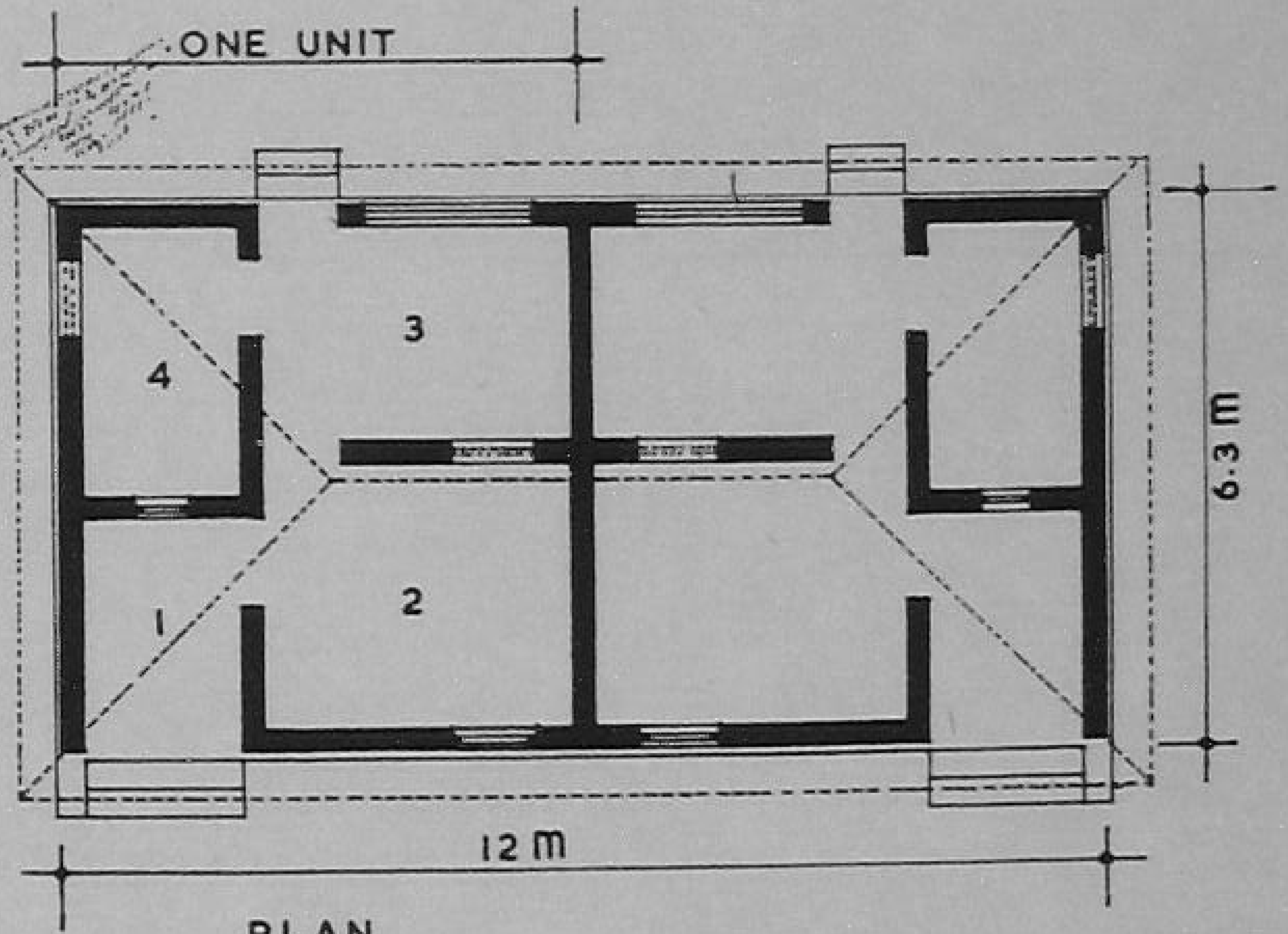
SECTION ON A.B.

TWO ROOMED HOUSE
AT VILLAGE DHARI—GUJARAT



1. VERANDAH . . . . . . 1.83 m x 2.75 m
2. LIVING ROOM . . . . 3.66 m x 3.0 m
3. MULTIPURPOSE RM. 3.66 m x 2.45 m
4. KITCHEN . . . . 1.83 m x 3.0 m

- PLINTH AREA/UNIT . . 38.8 sq.m

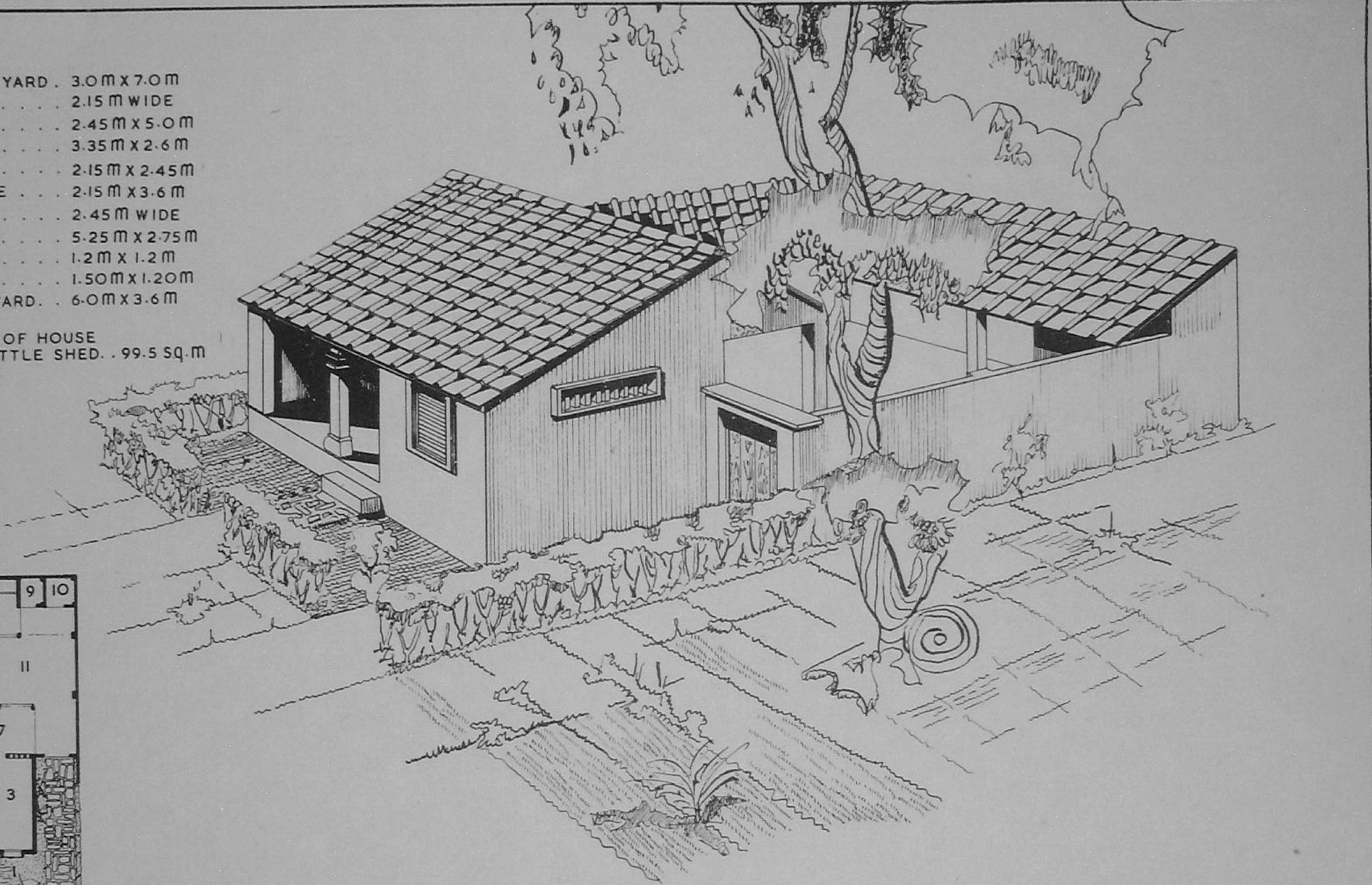


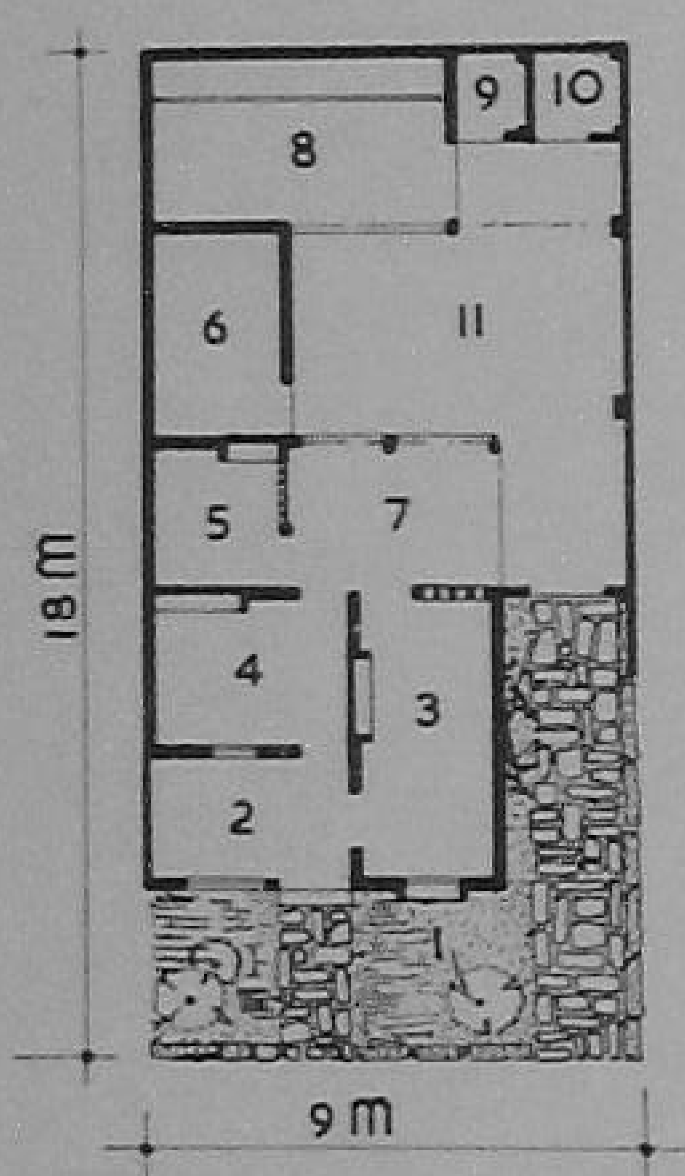
PLAN

TWO ROOMED HOUSE–KERALA

1. FRONT COURT YARD . 3.0m x 7.0m
2. VERANDAH. . . . . . 2.15m WIDE
3. ROOM . . . . 2.45m x 5.0m
4. ROOM . . . . 3.35m x 2.6m
5. KITCHEN. . . . . . . 2.15m x 2.45m
6. FODDER STORE . . . 2.15m x 3.6m
7. VERANDAH. . . . . . 2.45m WIDE
8. CATTLE SHED . . . . 5.25m x 2.75m
9. BATH. . . . . 1.2m x 1.2m
10. LATRINE. . . . . . 1.50m x 1.20m
11. REAR COURT YARD. . 6.0m x 3.6m

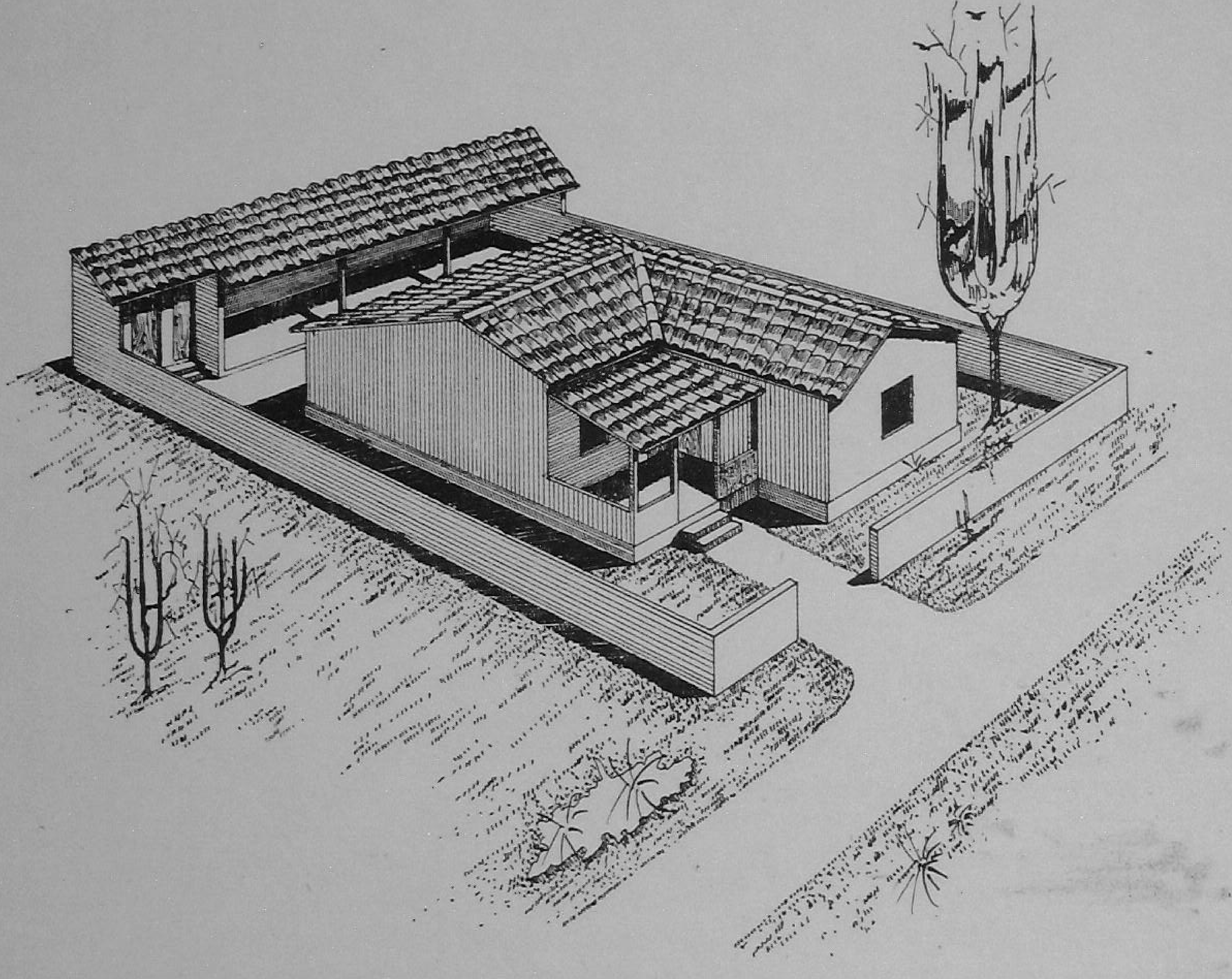
- PLINTH AREA OF HOUSE INCLUDING CATTLE SHED. . 99.5 sq.m



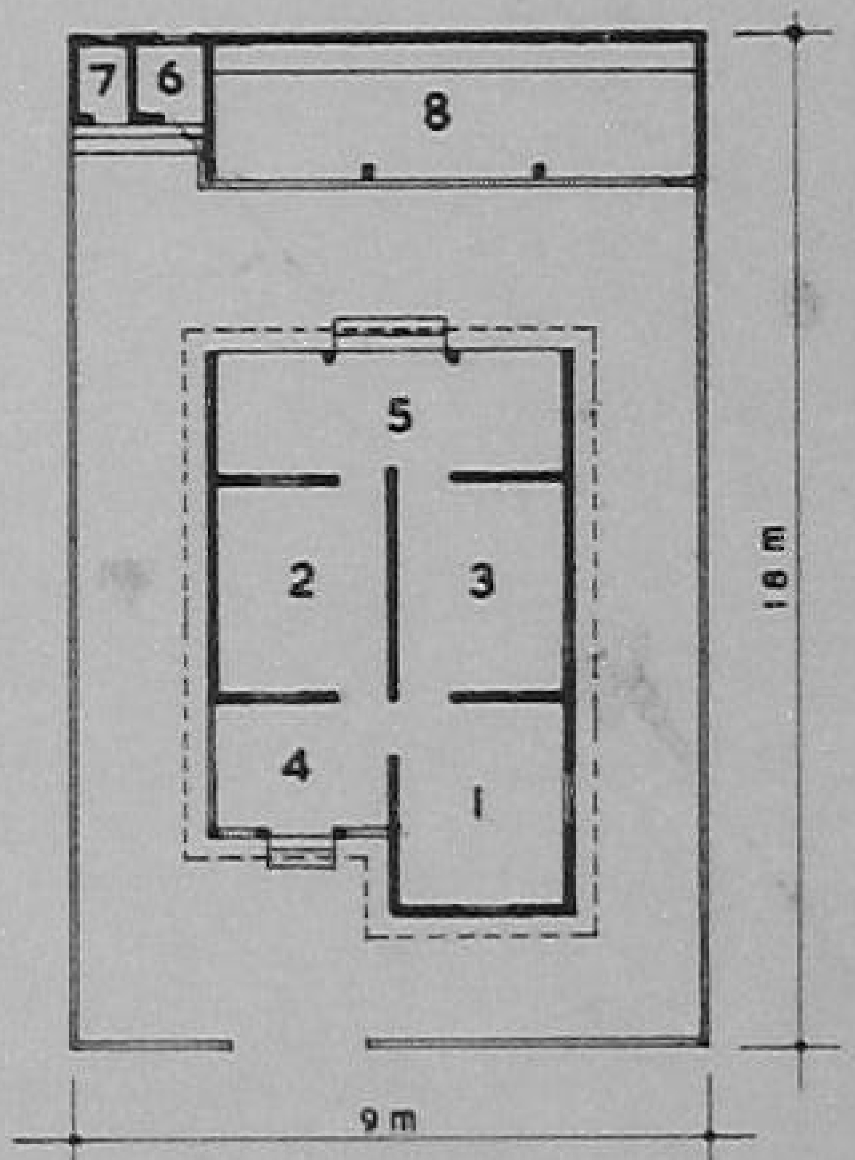


PLAN

TWO ROOMED HOUSE–UTTAR PRADESH

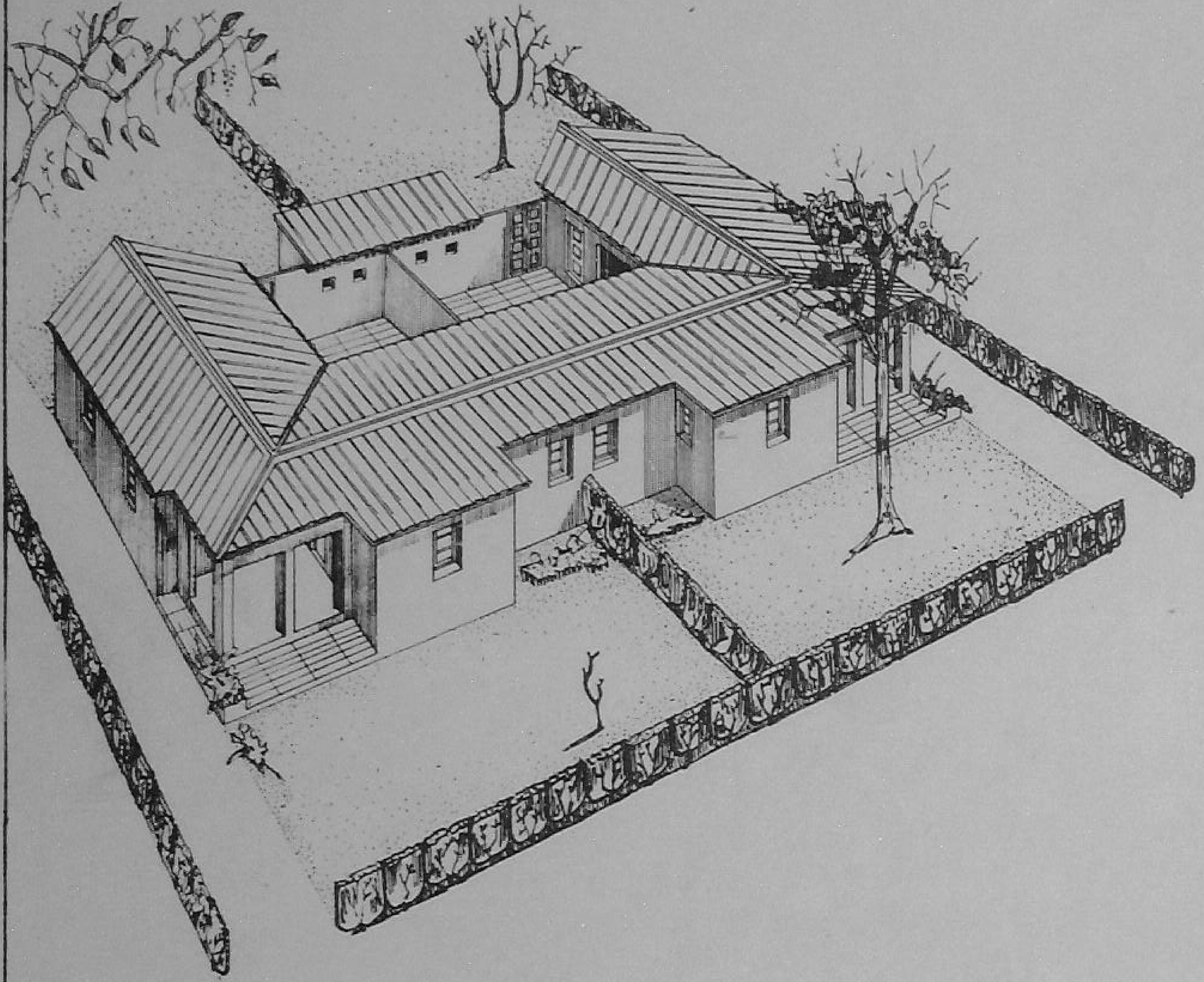


1. ROOM . . . . 3.0m X 3.66m
2. ROOM . . . . 3.0m X 3.66m
3. KITCHEN . . . . . . 3.0m X 3.66m
4. VERANDAH . . . . . 2.45m X 3.35m
5. VERANDAH . . . . . 2.15m X 6.4m
6. BATH . . . . 1.2m X 1.2m
7. LATRINE . . . . . . 0.9 m X 1.2m
8. CATTLE SHED & FODDER STORE . . 2.45m X 8.8m



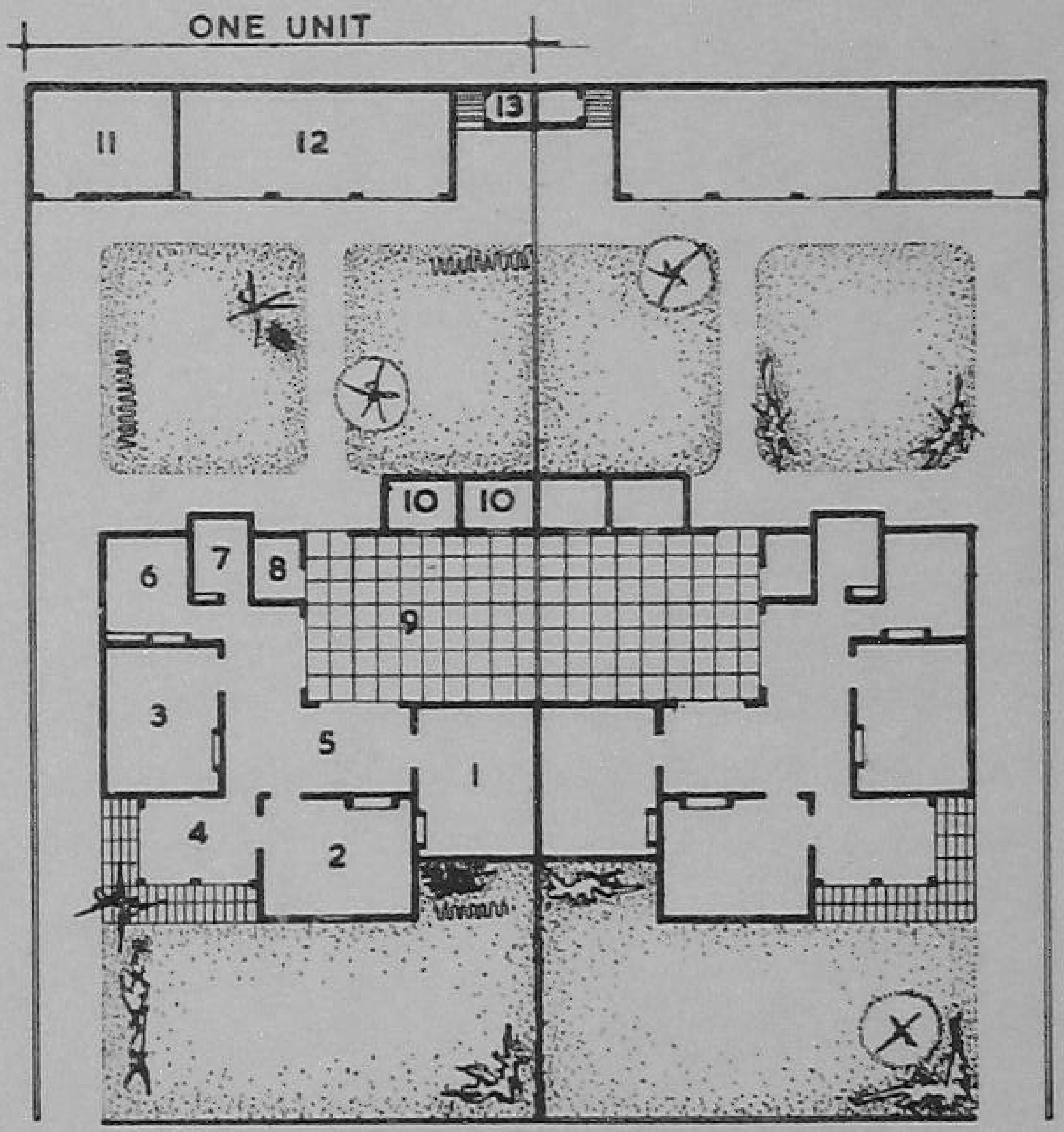
PLAN

A VILLAGE HOUSE
(MADHYA PRADESH)



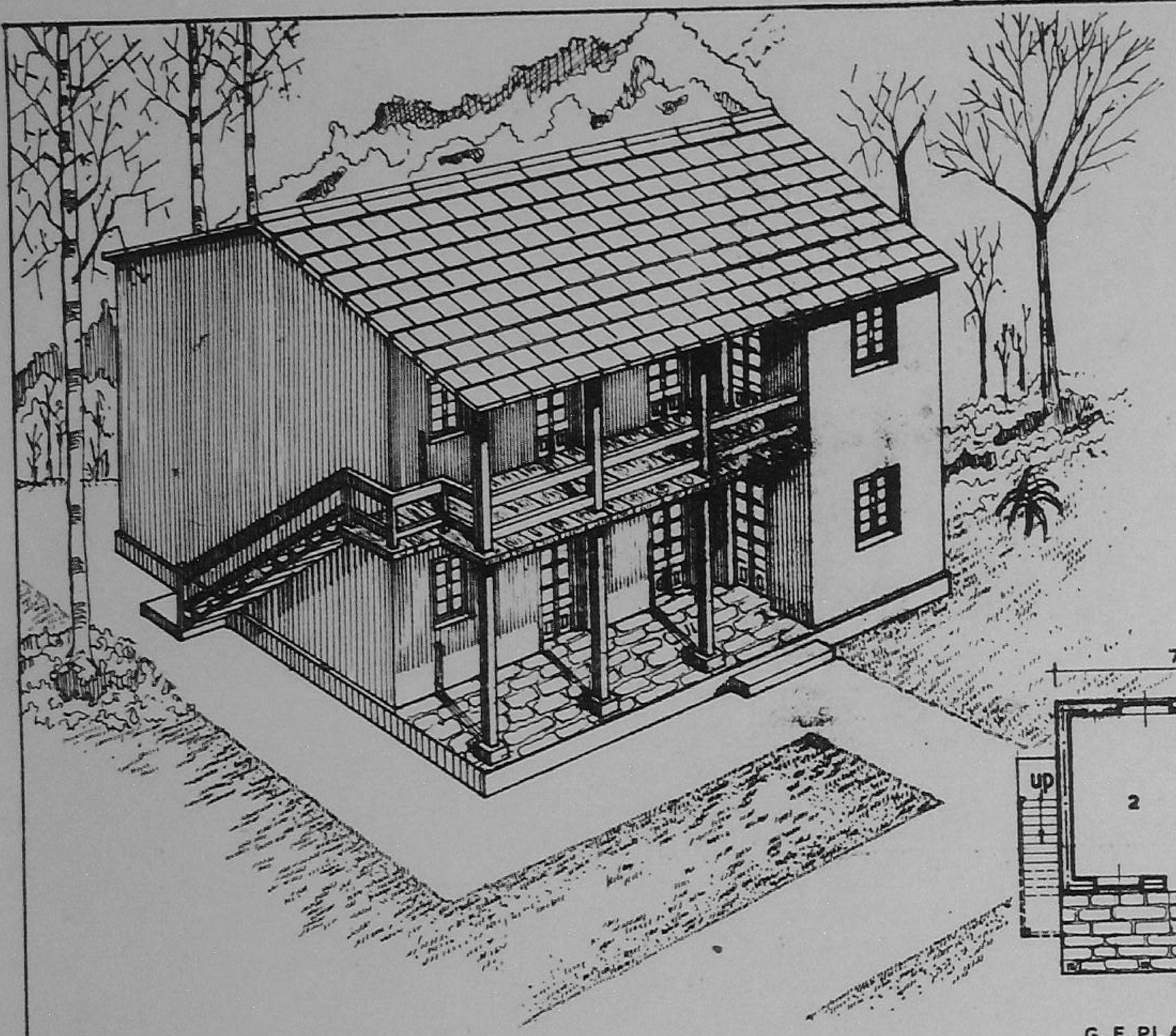
- 1,2,3 ROOM. . . . . 4.25 m x 3.35 m
- 4,5 FRONT & REAR VER. . 2.45 m WIDE
- 6. KITCHEN. . . . . 2.45 m x 3.0 m
- 7. STORE. . . . . 1.8 m x 2.45 m
- 8. BATH. . . . . 1.3 m x 1.8 m
- 9. COURT YARD. . . . . . . 6.0 m x 4.8 m
- 10. GRAIN STORE. . . . . . 2.15 m x 1.5 m
- 11. FODDER STORE. . . . . 4.25 m x 3.0 m
- 12. CATTLE SHED. . . . . . 9.0 m x 3.0 m
- 13. LATRINE. . . . . 1.05 m x 1.2 m

- • PLINTH AREA OF THE HOUSE. 107 sq.m } PER UNIT
- • PLINTH AREA OF CATTLE SHED. . . . . 50 sq.m } PER UNIT



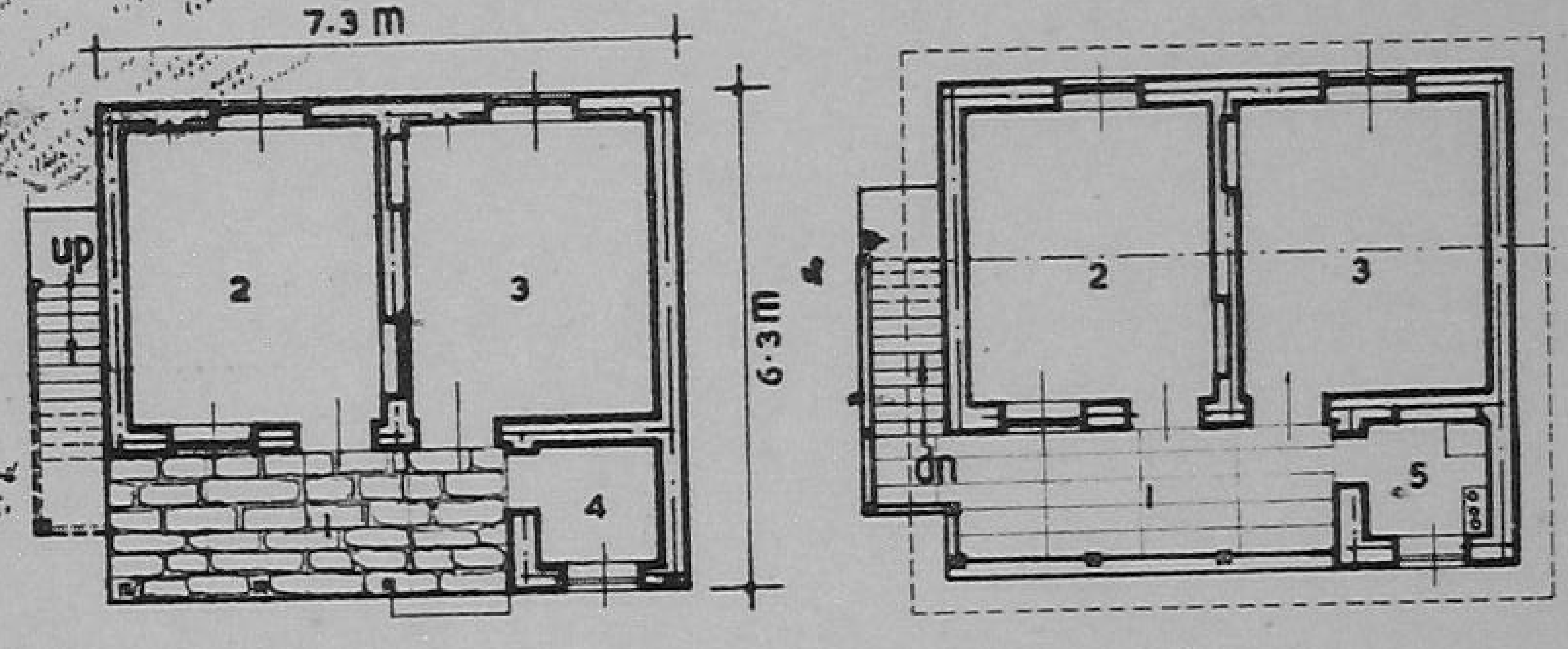
PLAN

THREE ROOMED HOUSE



1 VERANDAH.....1.83 m WIDE
2 ROOM..........3.0 m X 3.66 m
3 ROOM..........3.0 m X 3.66 m
4 BATH..........1.52 m X 1.42 m
5 KITCHEN......1.52 m X 1.42 m

- PLINTH AREA...45.7 sq.m



G. F. PLAN

F. F. PLAN

DOUBLE STOREYED HOUSE — HIMACHAL PRADESH.

16 Typical Specifications and Layout Plans

16.1 Specifications

16.1.1 Specifications for rural areas are to be based on the locally available materials suitably improved by modern engineering techniques taking note of the climatic conditions. The specifications suitable for rural areas are described below for general guidance. Details of specifications have been given in Chapters 8 & 9.

1. **Foundations:**
   - (a) Mud concrete.
   - (b) Lime concrete,
   - (c) Rammed kankar or brickbats.

2. **Plinth:**
   - (a) Stone in mud,
   - (b) Sundried bricks in mud,
   - (c) Burnt bricks in mud or lime mortar,
   - (d) Stabilized soil.

3. **Walls:**
   - (a) Sundried bricks in mud,
   - (b) Rammed earth,
   - (c) Stabilized soil with lime and cement or bitumen as stabilizing agent (to be used with caution as quality and grading of soil and proper mixing of cement and compaction very much affect the successful construction).
   - (d) Burnt bricks in mud or lime mortar,
   - (e) Stone masonry in mud or lime mortar,
   - (f) Balli posts and ekra panels (in Assam and West Bengal).

4. **Roofing:**
   - (a) Flat mud roofing (in plains of Punjab, Rajasthan and Uttar Pradesh).
   - (b) Thatched roofing using thatch or palmyra leaves (The thatch or the palmyra leaves should be given preservative treatment as explained in Chapter 8).
   - (c) Country tile roofing.
   - (d) Mangalore pattern tile roofing (in Maharashtra, Gujarat, Madras, Kerala and Andhra Pradesh).
   - (e) Stone slab roofing (in Rajasthan).
   - (f) A. C. sheet or G. I. sheet roofing. The supporting truss may be of the nailed timber type as explained in Chapter 10.
   - (g) Slate roofing (in Himachal Pradesh) and other hilly areas.
   - (h) Jack arch or R. B. roofing.
   - (i) Guna tile roofing.
   - (j) Doubly curved shell roofing.
   - (k) Allahabad tile roofing.

5. **Flooring:**
   - (a) Rammed earth finished with mud plaster and gobri leaping.
   - (b) Brick on edge flooring.
   - (c) Stabilized soil flooring as explained in Chapter 9.
   - (d) Stone slab flooring.
   - (e) Lime concrete flooring.

6. **Doors and Windows:**
   - (a) Country wood door frame and battened and braced door shutters.
   - (b) Bamboo matting doors and windows (in West Bengal, Assam, etc.)

7. **Finishing:**
   - (a) Burnt brick or stone walls may be pointed with lime or cement mortar on the outside.
   - (b) Water proof mud plaster on mud walls outside.
   - (c) Mud plaster with gobri leaping on the inside.
   - (d) Lime plaster on inside in better class houses.

16.2 Lay out Plans

Typical Village layout plans and rural houses are on the following pages.

APPENDIX I

RURAL HOUSING SCHEMES

1. INTRODUCTION

1.1. This Appendix describes the various rural housing schemes under which loan and/or subsidy can be granted to villagers for the construction of new houses. improvement of existing houses, etc.

2. VILLAGE HOUSING PROJECTS SCHEME

2.1. Scope

2.1.1 The Village Housing Projects Scheme aims at improving the housing conditions in selected villages on the basis of aided-self-help. The financial assistance which is given in the form of loan is restricted to the minimum, while technical assistance and guidance is given free. The construction and improvement of houses is done within the framework of the layout Plan prepared by the State Rural Housing Cell.

2.2. Loans—Under the Village Housing Projects Scheme loan is available for the following purposes:

2.2.1 *Complete Rebuilding of Existing Houses or Construction of New Houses.*

(i) The loan granted will not exceed 80 per cent of the estimated cost of construction subject to a maximum loan of Rs. 3,000 per house.

(ii) Loans will not be granted to persons who intend to build houses estimated to cost more than Rs. 5,000.

2.2.2 *Improvement of Existing Houses*

(i) Loans will be granted for effecting such improvements as call for substantial expenditure, such as enlargement of living accommodation, construction of kitchen, store, cattle shed. latrine, re-flooring. re-roofing and provision of doors, windows and ventilators.

(ii) Loans will not be granted for improvement of houses which are likely to be demolished on the basis of layout plan drawn up for the village.

(iii) The quantum of loan will not exceed the amount permissible for a new house under 2.2.1

2.2.3 *Acquisition and Dressing of Land*

(i) State Governments are permitted to utilize part of the loan allocated to them for a year under the Scheme, for acquisition of land in those cases where extra land required for thinning out densities, provision of additional housing sites, streets, community buildings and other community facilities, cannot be provided by the villagers by mutual agreement among themselves, as also for dressing and levelling the land so acquired in order to make it fit for construction of houses.

(ii) Recovery of the cost from the beneficiaries will be made in 20 years.

2.2.4 *Provision of Open Developed Plots*

(i) State Governments are also permitted to utilize part of the loan advanced to them for a year under the Scheme, to provide open developed plots for such members of the village community as are not in a position to repay loans for the construction of houses to enable them to put up their huts with their own labour and resources.

(ii) The entire cost of the developed plots will be treated as loan to the individuals concerned.

(iii) State Governments are required to keep the cost of the developed plot as low as possible, so as to be within the repaying capacity of the individuals concerned, and it should in no case exceed Rs. 500 per plot.

2.2.5 *Conditions to be Fulfilled by Applicants for Loans*

(i) Applicants must be *bonafide* residents of the village in which the Scheme is being implemented.

(ii) They should be able and willing to contribute from their own resources at least 20 per cent of the cost of construction. Their contribution may be either in cash or in the shape of building materials or manual labour.

(iii) Applicants should be willing to mortgage the land and the house to the State Government or to give some other form of security acceptable to the State Government, until the loan with interest due is repaid in full.

(iv) Applicants should be willing to build their houses generally in accordance with the layouts, designs and specifications prescribed by the State Government, with such modifications as may be necessary to suit individual requirements.

2.3 Grants—Under the Village Housing Projects Scheme, grants are available to State Governments for the following purposes :

2.3.1 *House Sites for Landless Agricultural Workers*

(i) The State Governments can use up to about 1/3 of their annual outlay for the Scheme for acquiring or enabling the Village Panchayats and Panchayat Samities to acquire additional land to be made available as house-sites for landless agricultural workers.

(ii) The labour required for development of the land acquired should be provided by the beneficiaries themselves on a voluntary basis.

(iii) A modest portion of the cost of the house-sites say 20 per cent to 25 per cent should be recovered from the beneficiaries in convenient instalments, which may be fixed by the State Governments in the context of the situation prevailing in the villages of the respective States. These recoveries to be effected through the Panchayats may be retained by the Panchayats, for the improvement of the sanitation and environmental hygiene of the villages concerned.

(iv) The entire expenditure incurred by a State Government in providing house sites is advanced to them as outright grant.

2.3.2 *Streets and Drains*

(i) The State Government can also utilize up to about 1/6 of their annual outlay for the Scheme for provision of streets and drains in the villages selected for development under the Scheme. The entire expenditure is treated as Central Grant. It has been left to the State

Governments themselves to lay down the precise standards of development, ceiling for the expenditure on provision of these amenities and other relevant matters, with a view to ensuring that the limited funds available for the purpose are used to the maximum advantage.

2.3.3 *State Rural Housing Cell*

(i) For implementing Village Housing Projects Scheme the State Governments have set up Rural Housing Cells in every State. These Cells draw up layout plans for selected villages, prepare designs and specifications for houses and provide technical guidance to local authorities in the execution of the projects under the Scheme.

(ii) Government of India meets 50 per cent of the expenditure on the salary and allowances (including travelling allowance) of the staff actually employed in these Cells subject to the following maxima:

States	Maximum Central Assistance per year
(1) States with a Second Plan allocation of villages not exceeding 200	Rs. 35,000
(2) States with a Second Plan allocation of villages from 201 to 450	Rs. 40,000
(3) States with a Second Plan allocation of villages exceeding 450	Rs. 50,000

(iii) *Additional Overseers*—The State Governments may appoint additional Overseers to advise villagers about the use of locally available building materials and construction methods and to perform such other duties in connection with the implementation of the Village Housing Projects Scheme as may be entrusted to them. 50 percent of the amount spent by the State Governments on their pay and allowances (including travelling allowance) will be given by the Central Government as grant. The total expenditure incurred by the State Government during a particular year on appointment of additional Overseers is not, however, to exceed 5 per cent of their outlay for the year under the Scheme.

2.4 Rules

2.4.1 Important provisions of detailed rules and regulations framed by various States under Village Housing Projects Scheme have been given in Table I.

2.4.2 *Union Territories*

The Ministry of Works, Housing and Supply of the Government of India have circulated to all the Union Territories a set of model rules for granting loans to villagers for the construction/improvement of houses under the Village Housing Projects Scheme. The important provisions of these rules are as follows:

1. **Maximum loan to be granted** — Rs. 3,000
2. **Sanctioning authority** — Chief Commissioner or any other officer authorised on his behalf.
3. **Disbursing authority** – B.D.O.
4. **No. of instalments** — 3 for construction of house and 1 to 2 for improvement of existing houses.
5. **Mode of disbursement** — (a) **Construction of New House**
   30% on mortgage deed, 50% at plinth level, 20% at roof level.
   (b) **Improvement of Existing House**
   Loans up to Rs. 400 are paid in one instalment. In case of loans exceeding Rs. 400, 50% payment is made on mortgage and the remaining 50% on half completion.
6. **Security for loan** — Mortgage of land and the house to be constructed or improved.
7. **No. of instalments for repayment of loan** — 20.
8. **Date of first instalment** — In case of construction of new house, 18 months after the disbursement of first instalment, and in case of improvement of existing houses, 12 months after the disbursement of first instalment of loan.

3. HOUSING SUBSIDIES FOR SCHEDULED CASTES, SCHEDULED-TRIBES AND OTHER BACKWARD CLASSES

3.1. The Ministry of Home Affairs, Government of India, have formulated the following rules for granting subsidy to Scheduled Castes, Scheduled Tribes and other Backward Classes.

3.1.1 The cost of the house should not exceed Rs. 1200, the State Government may, however, at their discretion, raise the ceiling cost to Rs. 1,600 per house in special cases and in black cotton soil areas, hilly regions and remote places. The ceiling cost may, however, be fixed as Rs. 1,600 in Jammu Province and Rs. 2,000 in other parts of Jammu & Kashmir State, in view of the need for building houses with superior specifications to withstand heavy snowfall, etc.

3.1.2 The Central Subsidy may be given on the basis of 75 per cent of the approved ceiling cost mentioned at 3.1.1. The remaining 25 per cent of the cost should be borne by the beneficiaries either in cash or building materials or by way of voluntary labour. Construction of costly houses in rural areas may be discouraged and no house, the estimated cost of which exceeds Rs. 3,000 per house, should be eligible for a subsidy under the Housing Scheme for the welfare of Backward Classes.

3.1.3 In the process of encouraging construction of housing colonies, instead of isolated houses, due precaution should be taken to ensure that it does not lead to segregation of harijans. For this purpose, it is suggested that 10 to 25 per cent of the sites should be reserved for non-Scheduled Castes. In order further to make sure that the required number of non-Scheduled Castes come forward to avail themselves of this allotment, they might be offered the same terms of assistance as are applicable to Scheduled Castes.

4. HOUSING SCHEMES FOR HANDLOOM WEAVERS

(Sponsored by the Ministry of Industry, Government of India).

4.1 Renovation and Enlargement of Existing Houses of Weavers

4.1.1 Loans may be given to weavers subject to a ceiling of Rs. 500 per house for the purpose of renovation and enlargement of existing houses, especially to accommodate the installation of frame looms.

TABLE I

RULES FRAMED BY STATE GOVERNMENTS FOR ADVANCING LOANS UNDER VILLAGE HOUSING PROJECTS SCHEME

Serial No.	Name of State	Maximum Amount of Loan to be advanced	Sanctioning Authority for the loan	Disbursing Authority	No. of Instalments	Mode of Disbursement of Instalments	Security	No. of Instalments in which loan is to be Repaid	Date of Repayment of First Instalment
1	2	3	4	5	6	7	8	9	10
1	Andhra Pradesh .	Rs. 2,000	Panchayat Samithi.	B.D.O.	3	(a) *Construction of New House.* (i) 40 per cent on mortgage of site. (ii) 40 per cent on construction up to roof level. (iii) 20 per cent on completion.	Mortgage of the land and house to be constructed and also where necessary hypothecation of some collateral security, acceptable to Panchayat Samithi.	20	After 18 months from the date on which first instalment of loan is disbursed.
					2	(b) *Improvement of Existing House.* (i) 60 per cent or mortgage of house and land. (ii) 40 per cent on completion.	Mortgage of the land and the house.		
2	Assam . .	Rs. 2,000	D.C./S.D.O. (Application through Assistant Project Officer).	D.C./S.D.O.	2	(i) 50 per cent on mortgage of land. (ii) 50 per cent of utilization of the first instalment.	Mortgage of land and house to be constructed or improved. (In some cases security of additional land).	18	Within 31st March of Second financial year from the date of payment of first instalment of loan.
3	Bihar . . .	Rs. 2,000	Collector or any other officer specially authorised.	P.E.O./B.D.O.	2	(i) 50 per cent after investment of 20 per cent of the cost by the beneficiary. (ii) 50 per cent when construction reaches roof level.	Mortgage of land and house to be constructed.	19	After 12 months from the date of drawal of first instalment.

4. Gujarat	No rules framed so far				Rules framed by former Bombay State are being followed			
5 Jammu & Kashmir	No rules framed so far.							
6 Kerala	Rs. 2,000	B.D.O. up to Rs. 1,500: Revenue Divisional Officer full powers.	B. D. O.	3	(*i*) 20 per cent on mortgage of land, (*ii*) 50 per cent on plinth level, (*iii*) 30 per cent on roof level.	Mortgage of land and house to be constructed or reconstructed.	20	After 12 months from the date of drawal of first instalment.
7 Madhya Pradesh	Rs. 2,000	Collector (Application throgh B. D. O.)	B. D. O.	3	(*i*) 50 per cent on execution of mortgage deed, (*ii*) 40 per cent on construction reaching plinth level (or half the work in case of improvement). (*iii*) 10 per cent on completion.	Mortgage of land and house to be built or improved. In case of loans exceeding Rs. 1,000, in addition, personal security.	20	18 months after payment of first instalment.
8 Madras	Rs. 2,000	B. D. O. or Commissioners of Panchayat Unions	B. D. O. or Commissioners of Panchayat Unions	3	(*i*) $33\frac{1}{3}$ per cent on mortgage deed, (*ii*) $33\frac{1}{3}$ per cent at plinth level in case of new construction and when improvements to a value of 50 percent of loan sanctioned are done in case of improvement of existing houses. (*iii*) $33\frac{1}{3}$ per cent at roof level in case of new construction and when the improvements have been completed in case of improvement of existing houses.	Mortgage of land and the house to be constructed or improved.	20	6 months after completion of house or 18 months from date of disbursement of first instalment which ever is earlier.

Serial No.	Name of State	Maximum Amount of Loan to be advanced	Sanctioning Authority for the loan	Disbursing Authority	No. of Instalments	Mode of Disbursement of Instalments	Security	No. of Instalments in which loan is to be Repaid	Date of Repayment of first Instalment
9	Maharashtra	Rs. 2,000 for construction of new house, Rs. 1,000 for improvements	B. D. O.	B. D. O.	3	(a) *For Construction of New house.* (for a loan of Rs. 2,000).			
						(i) First instalment Rs. 300.	Mortgage of land and house to be constructed or improved.	20	Second anniversary of the day of advancing loan.
						(ii) Second instalment Rs. 800.			
						(iii) Third instalment Rs. 900. In the case of loan for a sum less than Rs. 2,000/- the first instalment shall be Rs. 300 and the second and the third instalments shall be based on *prorata* basis.			
						The second and third instalments of loans shall be granted only on satisfying that amount already disbursed is properly and fully utilized for construction of house and after obtaining the certificate from an officer not below the rank of the Overseer of the Panchayat Samithi or Zilla Parishad accordingly.			
9	Maharashtra—contd.				2	(b) For *improvement of Existing House.* (i) 50 per cent before commencement. (ii) 50 per cent on 1/2 completion.			

10	Mysore	Rs. 2,000 for new house, Rs. 1,000 for improvement.	P.E.O./B.D.O.	P.E.O./B.D.O.	5	(i) 10 per cent at foundation level. (ii) 20 per cent at plinth level. (iii) 20 per cent at lintel level. (iv) 40 per cent at roof level. (v) 10 per cent at completion.	Mortgage of house-site and the house to be constructed or reconstructed.	20	
11	Nagaland		No rules framed so far.						
12	Orissa	Rs. 1,500	Collector (Application through B.D.O.).	B.D.O.		The disbursing authority will fix the amount of instalments and the dates on which they are payable.	Mortgage of house-site and the house to be constructed.	20	12 months after payment of first instalment.
13	Punjab	Rs. 2,000	B.D.O.	B.D.O.	2 (a)	*Construction of New House* (i) 50 per cent at plinth level. (ii) 50 per cent at roof level. NOTE—If a surety is also produced the loan can be given in one instalment in execution of a bond.	Mortgage of land and the house to be constructed or improved.	20	After 18 months from the date of sanction of first instalment.
					2 (b)	*Improvement of Existing House* (i) 50 per cent on commencement. (ii) 50 per cent on 1/2 completion.			

Serial No.	Name of State	Maximum Amount of Loan to be advanced	Sanctioning Authority for the loan	Disbursing Authority	No. of Instalments	Mode of Disbursement of Instalments	Security	No. of Instalments in which loan is to be Repaid	Date of Repayment of First Instalment
						NOTE—If a surety is also produced the loan can be given in one instalment.			
14	Rajasthan	Rs. 2,000	Panchayat Samiti	Panchayat Samiti	2 or 3	Loan may be issued in 2 instalments Rs. 1000/- on mortgage of plot or personal security and Rs. 1000/- when work comes to roof level. However, Panchayat Samities determine their own mode of payment and the loan is usually given in 3 equal instalments.	Mortgage of land and the house to be constructed or improved.	20	Second anniversary of the date of drawal of loan.
15	Uttar Pradesh	Rs. 2,000	District Planning Officer	B.D.O.	3	(*i*) 20 per cent on sanction of loan. (*ii*) 50 per cent at plinth level. (*iii*) 30 per cent at roof level. NOTE — Loans up to Rs. 250/- may be given in one instalment.	Mortgage of land and the house to be constructed or improved. Additional personal security required if the man has no cultivated land.	10 for loans up to Rs. 250 20 for loans exceeding Rs. 250.	After one year from the date of issue of loan. After 18 months from the date of issue of first instalment.
16	West Bengal	Rs. 1,000	B.D.O. upto Rs. 600/- S.D.O. upto Rs. 1,000/-.	B.D.O.	2	(*i*) 50 per cent on execution of bond. (*ii*) 50 per cent after the work has made adequate progress.	Loans up to Rs. 600/- against personal surety. Loans exceeding Rs. 600/- against security worth twice the value of loan.	10 for loans up to Rs. 600. 20 for loans exceeding Rs. 600.	After one year from the date of advance of loan.

4.2 Housing Colonies

4.2.1 For construction of housing colonies by Weavers' Cooperative Societies, financial assistance may be provided as under:

(a) The cost of construction of each house, including cost of land should not exceed Rs. 3,600.

(b) The grant will not exceed Rs. 1250.

(c) The weaver should contribute Rs. 350 or 10 per cent of the sanctioned cost whichever is higher.

(d) The balance of the ceiling will be given by way of loan.

4.2.2 Payment of subsidy and loan will be as under:

(a) **Subsidy**

(i) Rs. 800 when construction reaches roof level.

(ii) Rs. 450 after submission of audited accounts of cost of construction.

(b) **Loan**

(i) 1/3 along with the sanction of the scheme.

(ii) 1/3 when construction reaches plinth level.

(iii) 1/3 when construction reaches roof level.

4.2.3 The entire cost of providing amenities, such as water supply, drainage, etc, will be met as a loan and approved along with the first instalment of the loan admissible towards the cost of houses.

4.2.4 The loan will be repayable in 25 equated annual instalments commencing from the first anniversary of the date of drawal of the entire loan. The loans will carry the normal rate of interest.

5 RURAL HOUSING SCHEMES AT A GLANCE

LOANS TO VILLAGERS

A. VILLAGE HOUSING PROJECTS SCHEME

1. *Complete Rebuilding of existing houses/New Houses*—

(*a*) Government loan assistance $66\frac{2}{3}$ per cent of the cost of the house subject to a maximum of Rs. 2,000. In some States the maximum limit is less than Rs. 2,000.

(*b*) Villagers' contribution $33\frac{1}{3}$% in shape of labour, materials, or cash.

(*c*) Period of prepayment 20 years normally. In some States it is less than 20 years.

2. *Improvement of existing Houses*—

(*a*) For enlargement of living accommodation, construction of kitchen, store, cattle-shed, latrine, reflooring, reroofing, doors, windows and ventilators.

(*b*) Pattern of loan assistance as under 1 above.

3. *Acquisition and Dressing of Land*—

(*a*) For acquisition and dressing of land, where extra land required for thinning out densities and community facilities cannot be provided by villagers by mutual agreement.

(*b*) Recovery of the cost from the beneficiaries in 20 years.

4. *Open Developed Plots*—

(*a*) For providing open developed plots to poorer sections of the society.

(*b*) Cost not to exceed Rs. 500 per plot.

(*c*) Entire cost treated as loan.

(*d*) Recovery in 20 years.

(*e*) Beneficiary to put up hut with his own labour and resources.

B. HOUSING SCHEMES FOR HANDLOOM WEAVERS

1. *Renovation and Enlargement of Existing Houses*—

(*a*) Loans up to Rs. 500 can be given.

GRANTS TO STATES FOR VILLAGERS' BENEFIT

A. VILLAGE HOUSING PROJECTS SCHEME

1. *House sites for Landless Agricultural Workers*—

(*a*) Amount of grant equal to about 1/3 of annual outlay for the scheme.

(*b*) For acquiring additional land to be made available as house sites for landless agricultural workers.

(*c*) Labour required for development to be provided by beneficiaries.

(*d*) 20% to 25% of the cost of the house site to be recovered from beneficiaries in convenient instalments and utilized for improvement of the environmental hygiene of the village.

2. *Streets and Drains*—

(*a*) Amount of grant equal to about 1/6 of annual outlay on the Scheme

(*b*) For provision of streets and drains, precise standards of development to be prescribed by States.

B. HOUSING SUBSIDIES FOR BACKWARD CLASSES

1. *Construction of Houses*—

(*a*) Ceiling cost of houses Rs. 1,200 to be raised to Rs. 1,600 and Rs. 2,000 in special cases.

(*b*) 75% of the cost of construction to be given as subsidy.

GRANTS TO STATES FOR TECHNICAL SERVICES

A. VILLAGE HOUSING PROJECTS SCHEME

1. *State Rural Housing Cell*—

(*a*) 50% of the expenditure on pay and allowances (including Travelling allowance) of Staff; additional overseers to be given as grant subject to certain maxima.

LOANS TO VILLAGERS	GRANTS TO STATES FOR VILLAGERS' BENEFIT	GRANTS TO STATES FOR TECHNICAL SERVICE
2. *Housing Colonies of Weavers*— (*a*) Cost of construction of each house including cost of land not to exceed Rs. 3,600. (*b*) The weaver should contribute Rs. 350 or 10 per cent of the sanctioned cost whichever is higher, apart from the maximum grant of Rs. 1,250 given by the Government. (*c*) The balance of the ceiling (*i.e.*, Rs. 3600-1250-350) will be given as loan. (*d*) Cost of providing amenities, such as water supply, drainage, etc, to be given as loan. (*e*) Period of repayment 25 years.	C. HOUSING SCHEMES FOR HANDLOOM WEAVERS 1. *Housing Colonies of Weavers*— (*a*) Ceiling cost of house Rs. 3,600. (*b*) Grant not to exceed Rs. 1,250 per house.	

References

1. "Village Housing Projects Schemes", New Delhi, Government of India, Ministry of Works, Housing and Rehabilitation, November, 1960.

2. Government of India, Ministry of Home Affairs No. 12/45/61-SCT. II, dated 14-2-1964.

3. "General Principles for Loans and Grants to Handloom Weavers", New Delhi, Government of India, Ministry of Industry, the All India Handloom Board.

APPENDIX II

EQUIVALENT METRIC UNITS AND CONVERSION FACTORS

Serial No.	Quantity	British Unit	Equivalent Metric Unit	Conversion Factor British to Metric	Conversion Factor Metric to British
1	2	3	4	5	6
1	Length	inch (in)	millimetre (mm)	25·400	0·0394
		inch (in)	centimetre (cm)	2·540	0·394
		foot (ft).	metre (m)	0·305	3·281
		yard (yd)	metre (m)	0·914	1·094
		furlong	kilometre (km)	0·201	4·971
		mile	kilometre (km).	1·609	0·621
		nautical mile (U.K.)	international nautical mile (n mile)	1·001	0·999
2	Area	square inch (in^2)	square centimetre (cm^2)	6·452	0·155
		square foot (ft^2)	square metre (m^2)	0·0929	10·764
		square yard (yd^2)	square metre (m^2)	0·836	1·196
		acre	hectare (ha)	0·405	2·471
		square mile (sq mile)	square kilometre (km^2)	2·590	0·386
3	Volume	cubic inch (in^3)	cubic centimetre (cm^3)	16·387	0·061
		cubic foot (ft^3)	cubic metre (m^3)	0·0283	35·315
		cubic yard (yd^3)	cubic metre (m^3)	0·765	1·308
		acre foot (acre ft)	Hectare metre (ha m)	0·123	8·107
4	Capacity	imperial gallon (gal)	litre (l)	4·546	0·220
5	Mass	pound (lb)	kilogram (kg)	0·454	2·205
		hundred-weight (cwt)	quintal (q)	0·508	1·968
		ton	metric tonne (t)	1·016	0·984
6	Linear Density	lb/ft	kg/m	1·488	0·672
7	Density (Mass/Volume)	lb/ft^3	kg/m^3	16·019	0·0624
		lb/in^3	g/cm^3	27·680	0·0361
8	Specific Volume	ft^3/lb	m^3/kg	0·0624	16·019
9	Momentum	lb ft/s	kg m/s	0·138	7·233

EQUIVALENT METRIC UNITS AND CONVERSION FACTORS—*Contd.*

1	2	3	4	5	6
10	Moment of Momentum	lb ft²/s	kg m²/s	0·0421	23·730
11	Moment of Inertia	in⁴	cm⁴	41·623	0·024
12	Section Modulus	in³	cm³	16·387	0·061
13	Force	lbf	kgf	0·454	2·205
14	Bending Moment	lbf ft	kgf m	0·138	7·233
		lbf in	kgf cm	1·152	0·868
15	Stress and Pressure	lbf/in²	kgf/cm²	0·0703	14·223
		lbf/ft²	kgf/m²	4·882	0·205
		tonf/ft²	tf/m²	10·937	0·0914
		tonf/in²	kgf/mm²	1·575	0·635
16	Power	horse power (hp)	kgf/m/s	76·040	0·0132
		horse power (hp)	kilowatt (kW)	0·746	1·341
17	Temperature	°F	°C	$(F-32)\ \frac{5}{9}$	$C \times \frac{9}{5} + 32$
18	Quantity of Heat	British Thermal Unit (Btu)	calorie (cal)	251·996	0·003 968
19	Consumption (Volume/Length)	gallon per mile (gal/mile)	litre per kilometre (l/km)	2·825	0·354
20	Consumption (length/Volume)	mile per gallon (mile/gal)	kilometre per litre (km/l)	0·354	2·825

NOTE—

1 kilogram (kg) = 1·072 seer
1 gram (g) = 0·085 7 tola
1 metric tonne (t) = 26·792 maunds

1 seer = 0·933 kilogram (kg)
1 tola = 11·664 gram (g)
1 maund = 0·037 3 metric tonne (t)

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